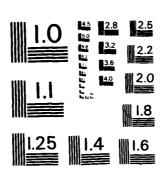
AD A132 357 JET ENGINE BURN-THROUGH INVESTIGATION VOLUME 2 ENGINE TESTS RAW DATA(U) MAGNAVOX CO FORT WAYNE IND FORT WAYNE DIV R W SCHUMACKER MAR 73 FAA-NA-72-96-2 DOT-FA12-575 F/G 21/5 NL													
			•									-	
						**************************************	j		langer or my				
		0 op 1				11					1.27	E an all	
									1	## ***********************************			
								. \$	· •			-	
3	1			# (Mark)		1						-	
					7		: :			******	September 1		

l



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS - 1963 - A

....

Regit. No. FAR-RD-72-149 Vol. II Schumerker, R. SOCUMENT IDENTIFICATION Final, Jun-Sept. 72 Control Dot-Fat2-525 Rd. No. FAR-No. 72-24 Max. '23 DISTRIBUTION STATEMENT Approved for public releases, Distribution Unlimited DISTRIBUTION STATEMENT ACCESSION FOR NITS GRAAI DISTRIBUTION STATEMENT Approved for public releases, Distribution Unlimited DISTRIBUTION STATEMENT ACCESSION FOR SECOND DISTRIBUTION STATEMENT ACCESSION FOR NITS GRAAI DISTRIBUTION STATEMENT ACCESSION FOR SECOND DISTRIBUTION STATEMENT ACCESSION FOR SECOND DISTRIBUTION STATEMENT ACCESSION FOR NITS GRAAI DISTRIBUTION STATEMENT ACCESSION FOR SECOND DISTRIBUTION STATEMENT ACCESSION FOR NITS GRAAI DISTRIBUTION STATEMENT APPROVED	PHOTOGRAPH THIS SHEET
ACCESSION FOR NTIS GRAA! DTIC TAB UNANNOUNCED JUSTIFICATION BY DISTRIBUTION / AVAILABILITY CODES DIST AVAIL AND/OR SPECIAL DISTRIBUTION STAMP 83 09 06 007 DATE RECEIVED IN DTIC	Approved for public releases Distribution Unlimited
DATE RECEIVED IN DTIC	ACCESSION FOR NTIS GRAAI DTIC TAB UNANNOUNCED JUSTIFICATION BY DISTRIBUTION / AVAILABILITY CODES DIST AVAIL AND/OR SPECIAL PART OF THE PROPERTY OF THE PROPE
	83 09 06 007
PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-DDA-2	DATE RECEIVED IN DTIC
DOCUMENT PROCESSING SHEET	

DTIC FORM 70A

JET ENGINE BURN-THROUGH INVESTIGATION VOLUME II: ENGINE TESTS RAW DATA

Richard W. Schumacker



MARCH 1973

FINAL REPORT

Document is available to the public through the National Technical Information Service, Springfield, Virginia 22151

Prepared for

DEPARTMENT OF TRANSPORTATION

830735 FEDERAL AVIATION ADMINISTRATION

Systems Research & Development Service
Washington D. C., 20591

The contents of this report reflect the views of the contractor, which is responsible for the facts and the accuracy of the data presented herein, and do not necessarily reflect the official views or policy of the FAA or Department of Transportation. This report does not constitute a standard, specification, or regulation.

The Federal Aviation Administration is responsible for the promotion, regulation and safety of civil aviation, and for the development and operation of a common system of air navigation and air traffic control facilities which provide for the safe and efficient use of airspace by both civil and military aircraft.

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FAA-RD-72-149, II	<u> </u>	5. Report Date
Jet Engine Burn-Through Inv	vestigation - Vol. II	March 1973
Engine Tests Raw Data		6. Performing Organization Code ASW-587
7. Author(s) R.W. Schumacker		8. Performing Organization Report No.
		FAA-NA-72-96
9. Performing Organization Name and Addre The Magnavox Company)	10. Work Unit No.
Government and Industrial G Fort Wayne Division	Froup	11. Contract or Grant No. DOT-FAT2-575
Fort Wayne, Indiana 46804	,	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address DEPARTMENT OF TRANSPORTATION	June - September 1972	
FEDERAL AVIATION ADMINISTRA		
Systems Research and Develow Washington, D. C. 20590	14. Spansoring Agency Code	

15. Supplementary Notes

This study was made under a contract administrated by the National Aviation Facilities Experimental Center, Atlantic City, N.J.

16. Abstract

The work performed during this program was directed toward determining the acoustic characteristics of simulated burn-through failures. To determine the feasibility of detecting this failure acoustically two types of jet engines (J-47 and J-57) were modified to simulate burn-through failures. Magnetic tape recordings of the modified engines were made to determine the extent of the acoustic spectrum, the relationship of engine speed to failure related sound pressure levels and acoustic spectrum, the effect of sensor location to detect the failure acoustically and characteristic acoustic spectra at burn-through. The recorded data was analyzed by real time spectrum analysis and mean square techniques. Results indicated that the simulated burn-through failure acoustic spectra consists primarily of broadband random noise above 5 kHz. It was also determined that sensor location is an important factor in detecting burn-through failures. Based on the results it is concluded that acoustic detection of a burn-through failure is feasible. Recommendations for a monitor and detector based on the results of this program have been included. Volume I contains the Sonic Analysis.

830735

Unclassified	Unclassified	302 04
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages 22. Price
Combustion Chamber Failure	Virginia 22151, fo	or sale to the public.
Jet Engine Combusters	Information Service	e. Springfield.
Sonic Engine Analyzer	be released to the	National Technical
Burner-Can Burn-Through		nlimited. Document may
I/. Key Words	16. Distribution Statement	

PREFACE

This report was prepared by the Government and Industrial Group, Fort Wayne Division, The Magnavox Company, Fort Wayne, Indiana, for the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey. The work was administered under the direction of Richard Hill, Project Engineer, Propulsion and Fire Protection Branch, Aircraft Safety Division, NAFEC. Appreciation is expressed to Mr. Hill and his staff for their valuable assistance while executing the tests at the NAFEC facility.

APPENDIX LIST

VOLUME II, ENGINE TESTS RAW DATA

Appendix	Title	Page
A	J-47 ENGINE	A-1
В	J-57 ENGINE (PORT)	B-1
С	COMBINED J-47 AND J-57 ENGINE TESTS	C-1
D	J-57 STARBOARD ENGINE FUEL LINE FAILURE	D-1
E	MICROPHONE CHARACTERISTICS	E-1
F	RECORDING AND ANALYSIS EQUIPMENT LIST	F-1

APPENDIX A

J-47 ENGINE

A.1 J-47 ENGINE, MODIFIED BURNER CAN HOLE COVERED

A series of three test runs were made on the J-47 engine with the modified burner can hole covered. Each test was recorded using five microphones placed as noted in the text. The three tests were run at the following engine speeds:

- (1) 70% RPM (46 in. Hg gage, diffuser case pressure)
- (2) 80% RPM (70 in. Hg gage, diffuser case pressure)
- (3) 90% RPM (97 in. Hg gage, diffuser case pressure)

The purpose of this test was to establish a reference to compare modified burner can closed hole sound energy levels at the three engine speeds with sound energy levels of the modified burner can with three sizes of open holes (1.5, 1.0, and 0.75-inch) at like engine speeds.

Analysis of the recordings made during the three runs is given on the following pages:

- (1) 70% run pages A-4 through A-12
- (2) 80% run pages A-13 through A-21
- (3) 90% run pages A-22 through A-28

A.1.1 Analysis

A.1.1.1 Sound Energy Levels

Output levels of microphones 1 through 5 were measured for RMS sound energy during each test run. Microphone 2 was a broadband instrumentation microphone and microphones 1, 3, 4, and 5 had a lower frequency response but were all of the same type. The data was converted to decibels by conversion factors detailed in Appendix F. Variations in RMS levels of microphones 1, 3, 4, and 5 are attributed to microphone location and proximity to engine machinery (i.e., fuel pumps, etc.).

The closed hole test measurements are representative of a normal engine. These measurements will be used as a reference to compare sound energy levels made during open hole tests which are representative of burner can failure. Microphone sound levels increased from 2 to 5 dB when engine speed was increased from 46 in. Hg to 70 in. Hg, and from 2 to 4 dB when engine speed was increased from 70 in. Hg to 97 in. Hg. Microphone 5 was farthest away from the engine and showed the most change while microphone 3 was closest and showed the least change. The

influence of background exhaust noise was apparent from the sound measurements.

A.1.1.2 Spectrum Analysis

The analysis bandwidth was 0 to 20 kHz for all microphones. In addition, the instrumentation microphone (No. 2) data was analyzed from 0 to 40 kHz. Discrete spectral content due to engine machinery was present in all grams, but as engine speed was increased, there was a noticeable change in broadband noise, the extent of which varied with microphone location. Microphone 5 contained the most broadband noise and microphone 3 the least. The major portion of the energy was below 10 kHz in all cases. Instrumentation microphone No. 2 showed discrete frequencies present up to 30 kHz and some broadband noise up to 40 kHz.

A.1.1.3 Mean Square Analysis

The data from each microphone was analyzed over bandwidths of 0 to 20 kHz and 5 to 20 kHz simultaneously, using mean square techniques. This method of analysis, when recorded, showed the summation of the total spectrum at any given time versus the summation of the spectrum above 5 kHz. Microphones 1, 2, and 3 showed very little variation between changes in engine speed while microphones 4 and 5 showed noticeable variation. The bulk of the spectral content is observed to be below 5 kHz.

A.1.2 Environmental Conditions

The three tests discussed in paragraph A.1 were performed at an ambient temperature of 61° F and 75% relative humidity.

A.1.3 Sound Energy Levels

The following tables list the sound energy levels of the five microphones at three engine test speeds:

Table A-1. Microphone Sound Energy Levels at 70% Engine RPM

	MI CROPHONE						
SOUND LEVEL	1	2	3	4	5		
RMS (mV)	13	3	14	12	9		
RMS (µBAR)	105	235	110	96	72		
dB (a)	114	121	115	114	111		

 $^{^{\}mathbf{a}}$ Reference = 2 x 10 $^{-4}$ μ BAR

Table A-2. Microphone Sound Energy Levels at 80% Engine RPM

	MI CROPHONE						
SOUND LEVEL	1	2	3	4	5		
RMS (mV)	23	5	18	22	16		
RMS (µBAR)	180	390	145	180	130		
dB (a)	119	126	117	119	116		

^aReference = $2 \times 10^{-4} \mu BAR$

Table A-3. Microphone Sound Energy Levels at 90% Engine RPM

	MICROPHONE						
SOUND LEVEL	1	2	3	4	5		
RMS (mV)	28	8	24	30	26		
RMS (µBAR)	220	620	190	240	210		
dB (a)	121	130 .	120	122	120		

^aReference = $2 \times 10^{-4} \mu BAR$

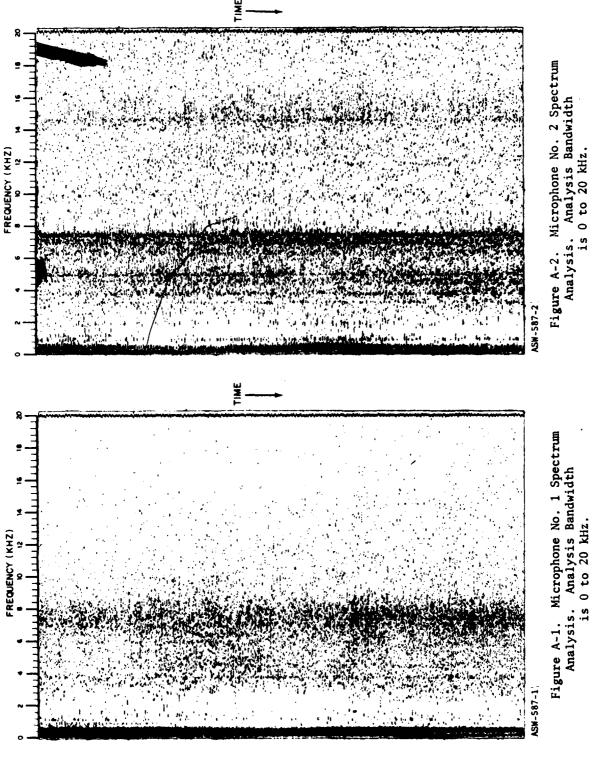
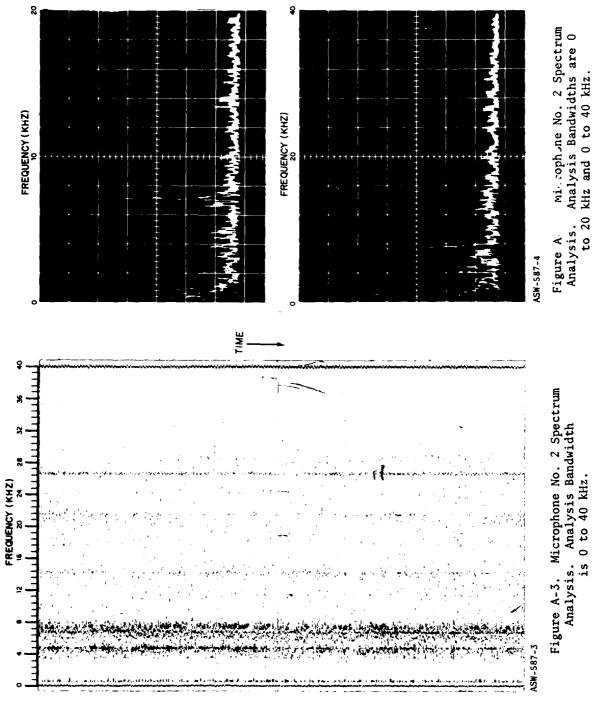


Figure A-2. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



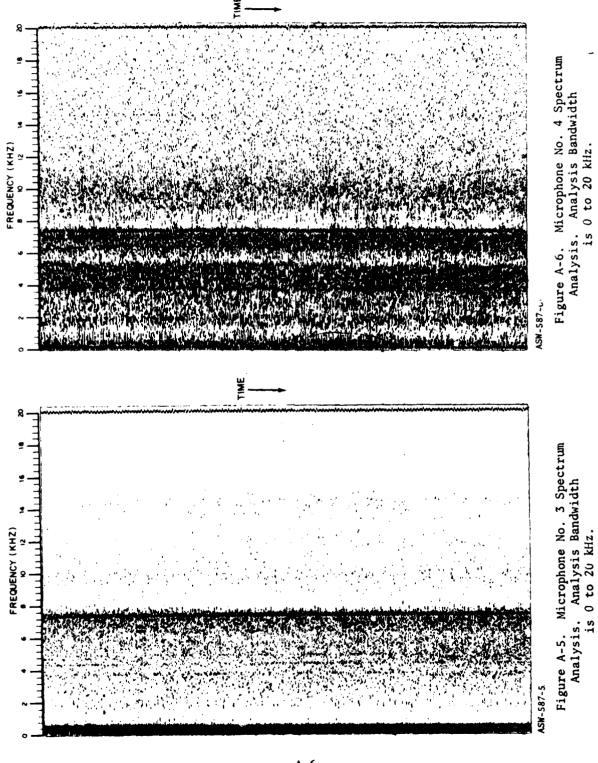


Figure A-6. Microphone No. 4 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

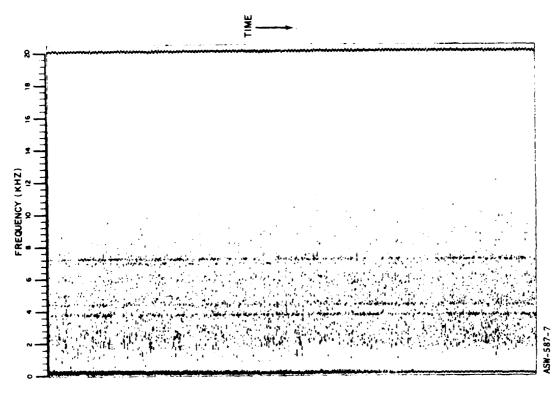
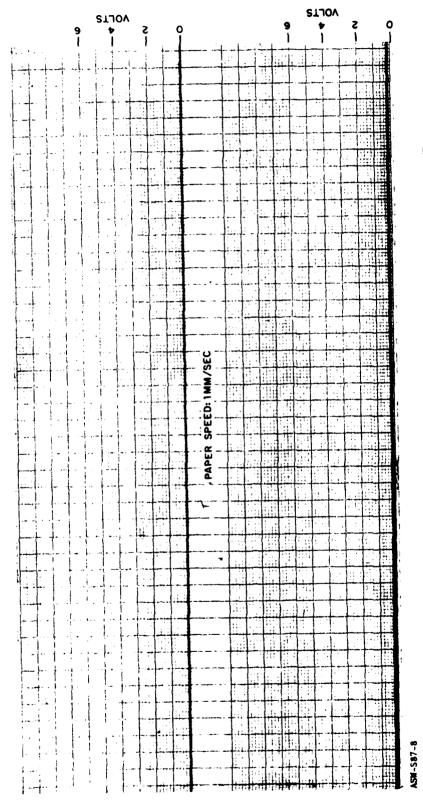


Figure A-7. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. Figure A-8.

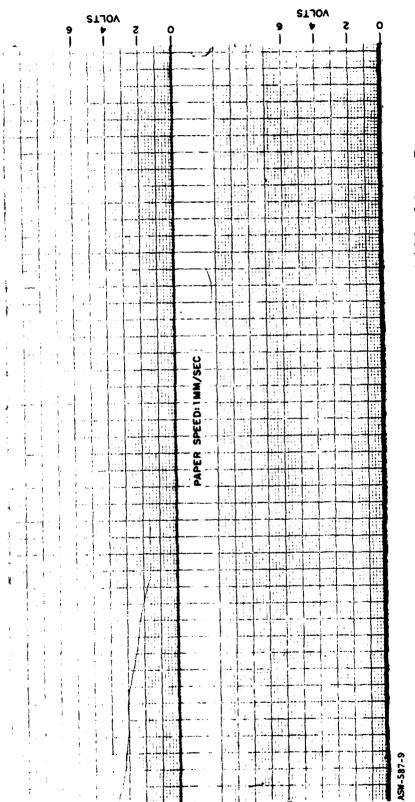
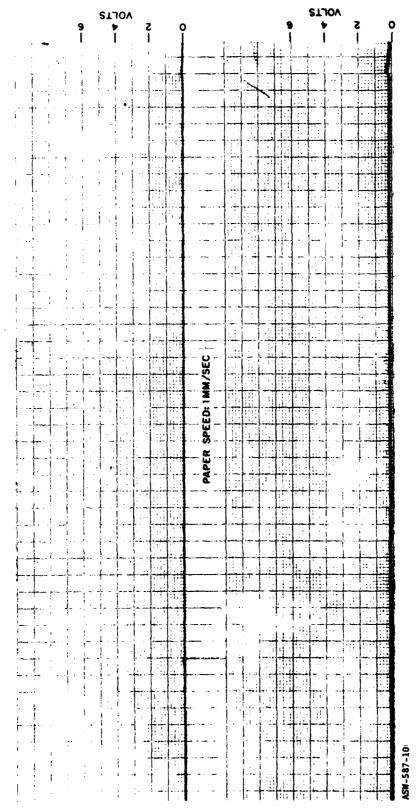
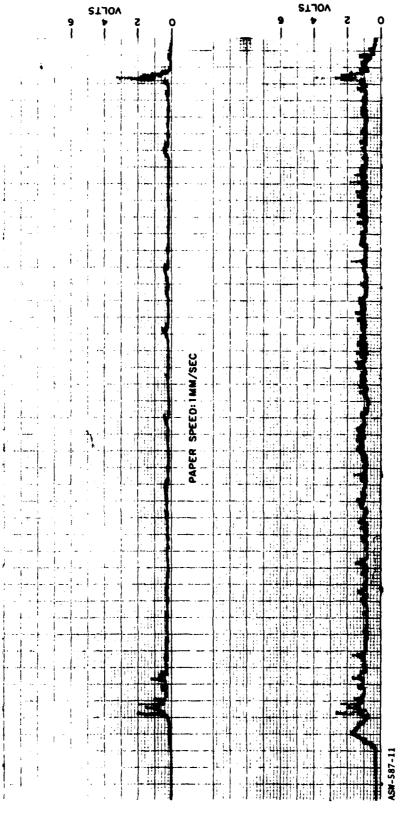


Figure A-9. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.



Microphone No. 3 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. Figure A-10.



Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. Figure A-11.

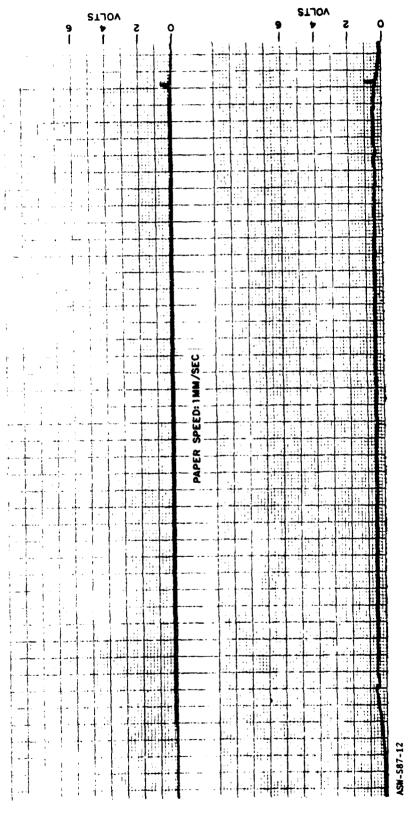
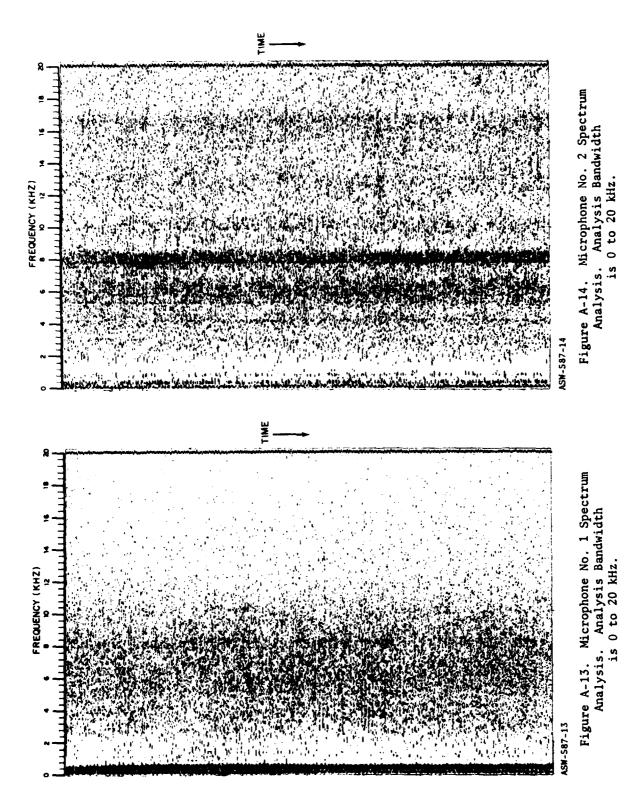
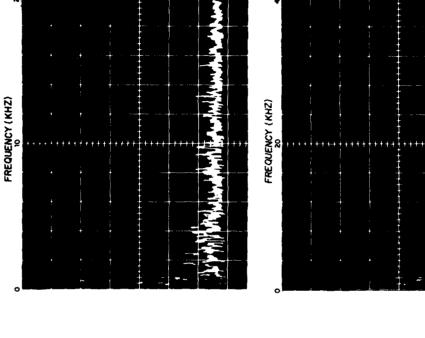


Figure A-12. Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.





FREQUENCY (KHZ)

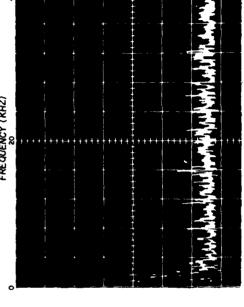
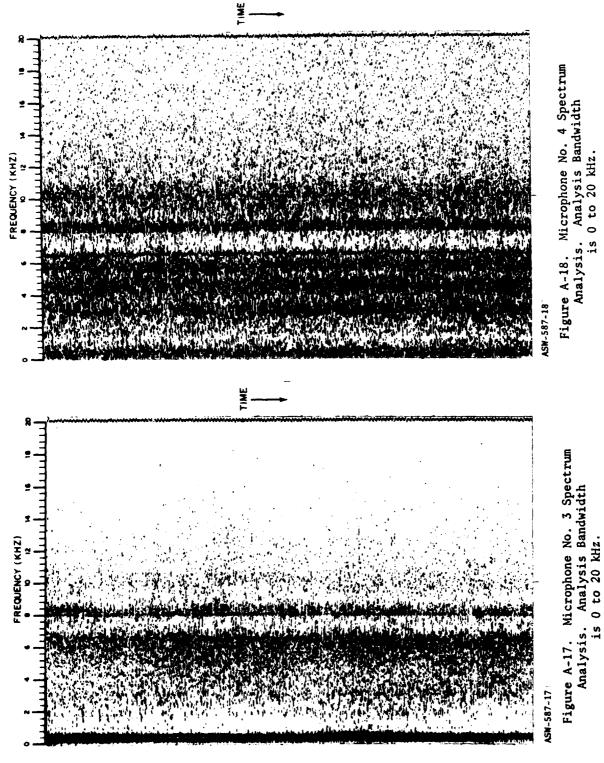


Figure A-16. Microphone No. 2 Spectrum Analysis. Analysis Bandwidths are 0 to 20 kHz and 0 to 40 kHz.

ASW-587-16

Figure A-15. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 40 kHz.

ASW-587-15,



A-15

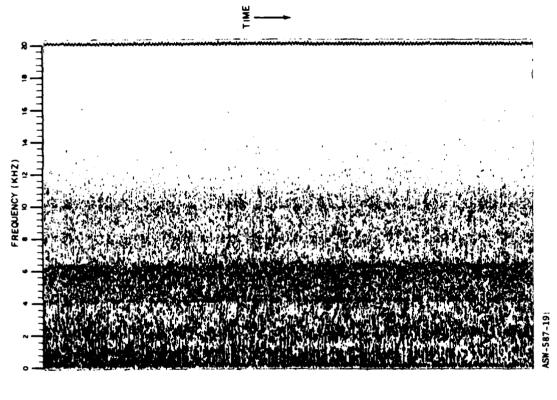


Figure A-19. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

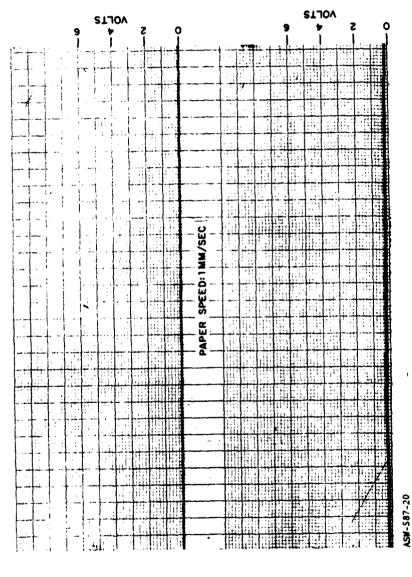


Figure A-20. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

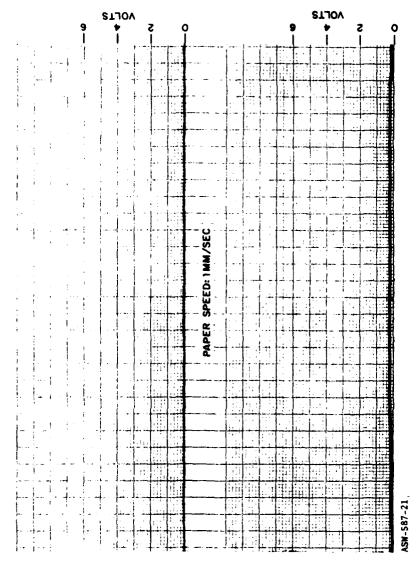


Figure A-21. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

.

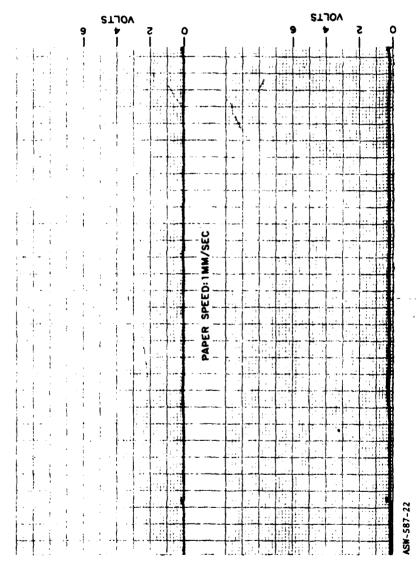


Figure A-22. Microphone No. 3 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

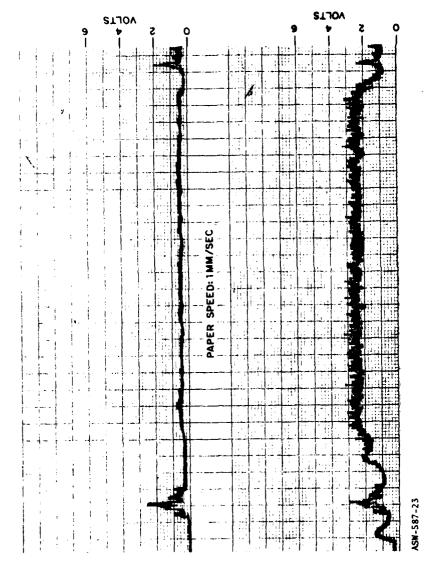


Figure A-23. Microphone No. 3 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

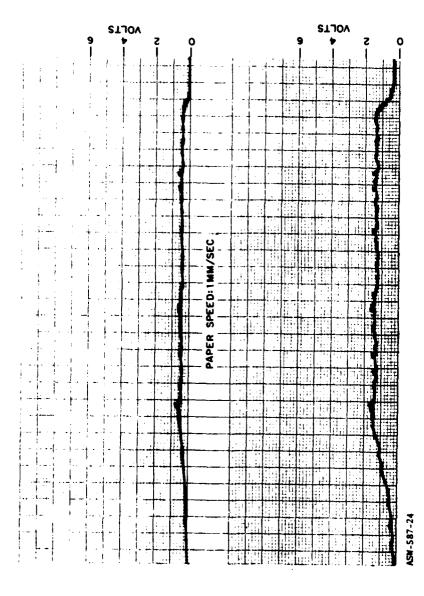


Figure A-24. Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

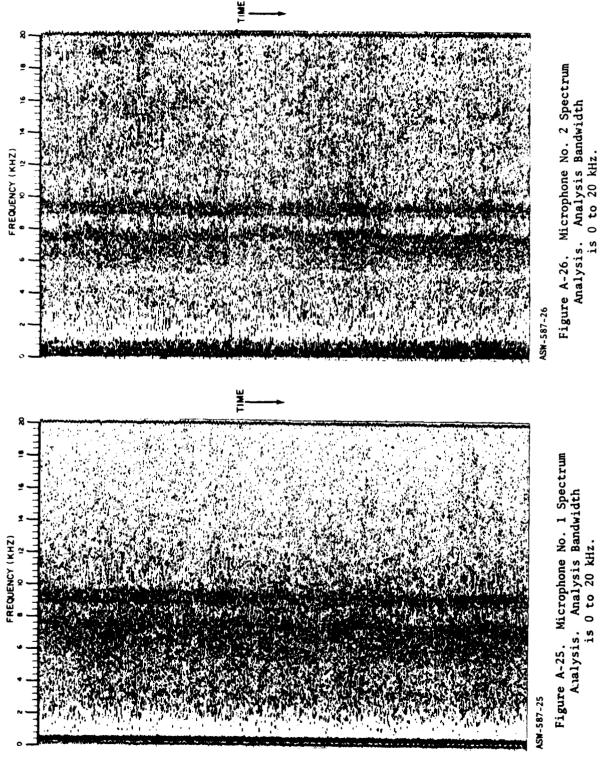


Figure A-26. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

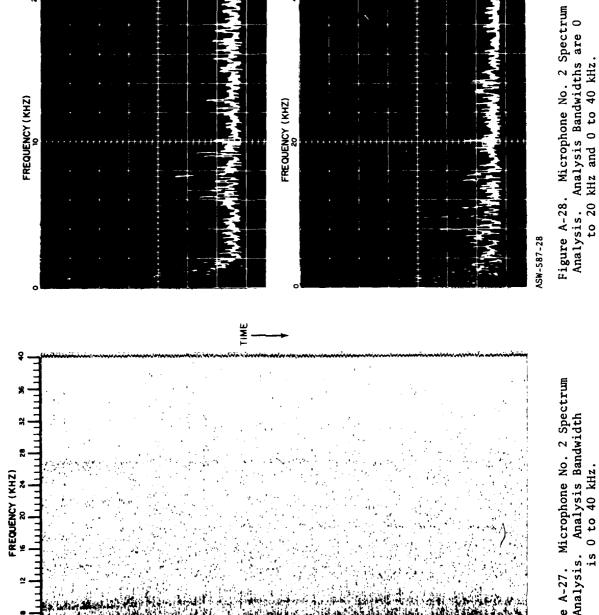


Figure A-27. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 40 kHz.

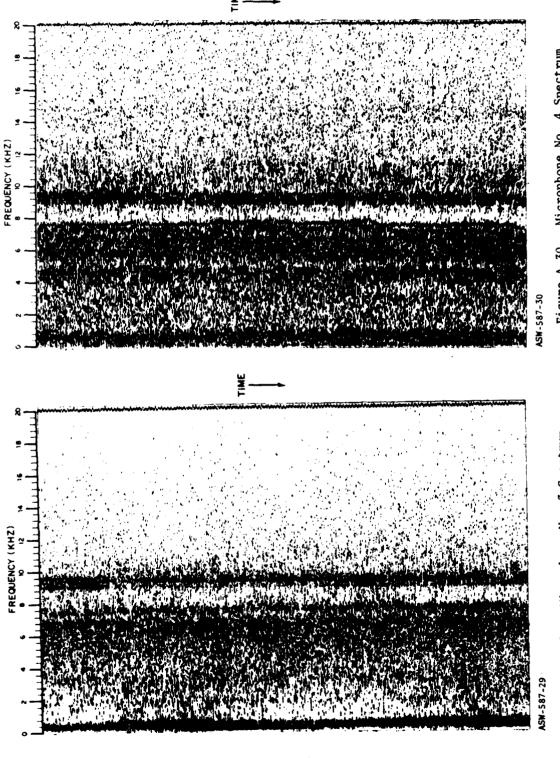


Figure A-30. Microphone No. 4 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz. Figure A-29. Microphone No. 3 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

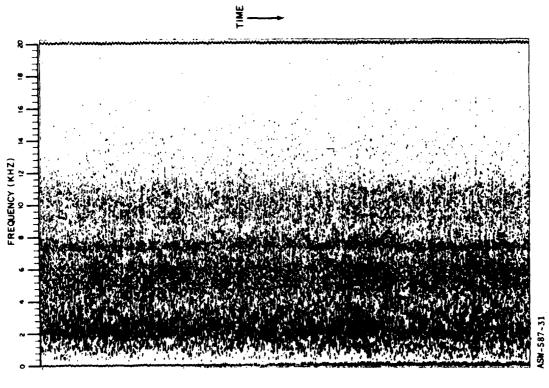
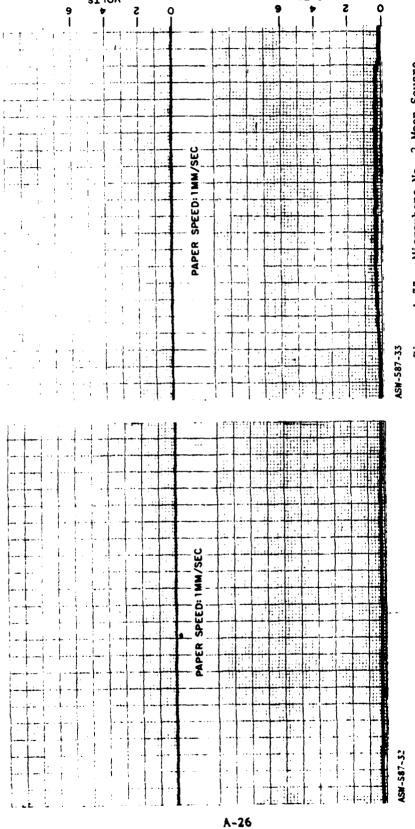


Figure A-31. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



VOLTS

Figure A-32. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

Figure A-33. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

0

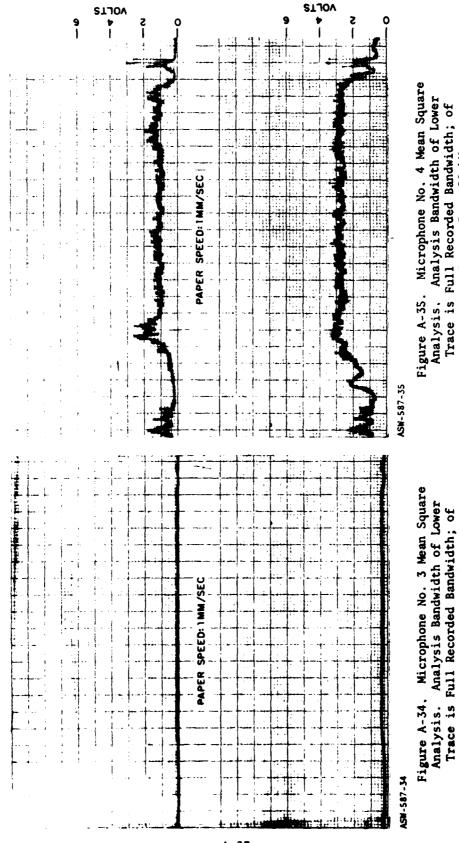


Figure A-35. Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

Upper Trace, 5 to 20 kHz.

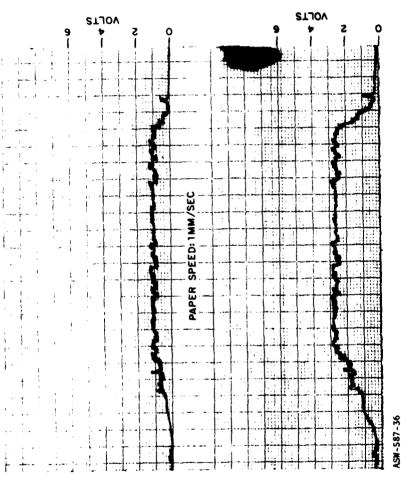


Figure A-36. Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

A.2 J-47 ENGINE, MODIFIED BURNER CAN HOLE OPEN - 1.5 INCH DIAMETER

A series of three test runs were made on the J-47 engine with the modified burner can hole masked to a 1.5-inch hole. Each test was recorded using five microphones located in the same positions as for the closed hole tests. The three tests were run at the following engine speeds:

- (1) 70% RPM (46 in. Hg gage, diffuser case pressure)
- (2) 80% RPM (70 in. Hg gage, diffuser case pressure)
- (3) 90% RPM (97 in. Hg gage, diffuser case pressure)

The purpose of this test was to determine the sound energy level differential between a closed hole on the modified burner can and a large open hole (1.5 inches in diameter) at like engine speeds.

Analysis of the recordings made during the three runs is given on the following pages:

- (1) 70% run pages A-32 through A-37
- (2) 80% run pages A-38 through A-43
- (3) 90% run pages A-44 through A-50

A.2.1 Analysis

A.2.1.1 Sound Energy Levels

Microphone sound levels increased 3 to 5 dB when the engine RPM was increased from 70% to 80% versus 2 to 5 dB on the closed-hole test. Microphone sound levels increased 1 to 3 dB when the engine RPM was increased from 80% to 90% versus 2 to 4 dB on the closed hole-test. The lowest sound energy occurred on microphone 5 which was farthest away from the hole. Microphone 1 had the highest sound level due to position and location. Sound levels of 27, 21, and 25 dB differentials for the three runs were noted on microphone 1 while the other microphone differentials were much less. Microphone 2 and 3 differentials were about equal as were their distances from the open hole. Microphone 4 had the least change.

A.2.1.2 Spectrum Analysis

As in the closed-hole test, discrete spectral content due to engine machinery was present in all grams. There was a very noticeable change in broadband noise the extent of which was dependent on microphone location. Noise up to 20 kHz was present in all grams, but was more pronounced in those microphones located on the engine mount. Instrumentation microphone No. 2 data was processed over seven analysis bandwidths in order to inspect for sustained discrete frequencies. As

the analysis bandwidth decreased and resolution increased, machinery frequency lines became apparent. The 0- to 100-Hz analyzing band, which had a resolution of 0.1 Hz, showed short, unstable discrete frequency lines. The noise content of microphone 2 was very dense up to 35 kHz before it decreased. Discrete frequencies in the 0- to 40-kHz microphone 2 gram were primarily masked out by the noise.

A 2.1.3 Mean Square Analysis

Microphones 1, 2, and 3 showed a marked increase in energy level from the closed-hole test. The differences were attributed to proximity to the open hole. Microphones 4 and 5, which displayed relatively high levels in the closed-hole tests, displayed the same characteristics in the open-hole tests, but at higher amplitudes. A lesser amount of energy over 5 kHz was noticeable at low engine speed, while at high engine speed the unfiltered recordings approximated the same amplitudes as the filtered recordings. The latter was not true for micrones 1 and 2, which were both located above the open hole. The latered data from these microphones exhibited approximately half the

Itered data from these microphones exhibited approximately half the amplitude of the unfiltered processed data.

A.2.2 Environmental Conditions

The three tests discussed in paragraph A.2 were performed at an ambient temperature of 61°F and 75% relative humidity.

A.2.3 Sound Energy Levels

The following tables list the sound energy levels of the five microphones at three engine test speeds:

Table A-4. Microphone Sound Energy Levels at 70% Engine RPM

SOUND LEVEL	MI CROPHONE					
	1	2	3	4	5	
RMS (mV)	300	22	92	40	32	
RMS (µBAR)	2400	1700	660	320	260	
dB (a)	141	139	131	124	122	

^aReference = $2 \times 10^{-4} \mu BAR$

Table A-5. Microphone Sound Energy Levels at 80% Engine RPM

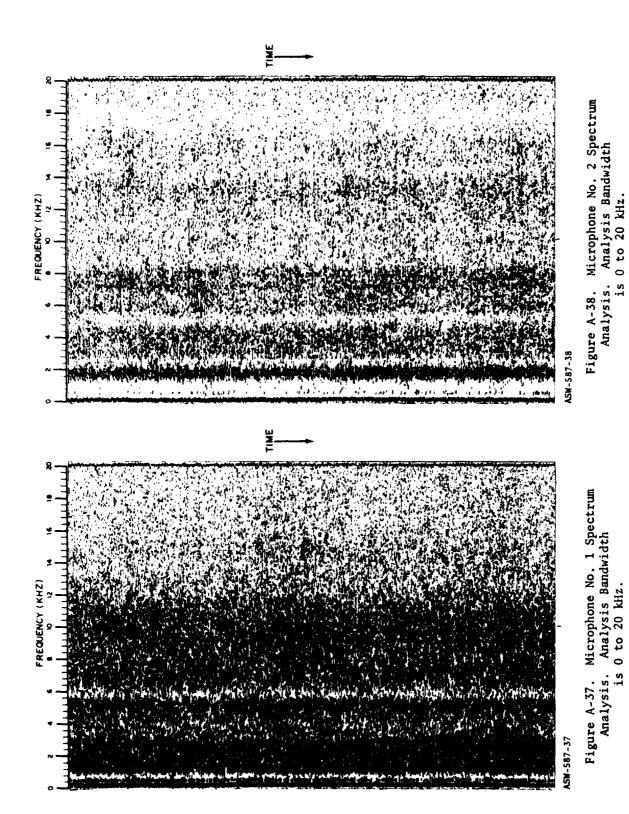
SOUND LEVEL	MICROPHONE					
	1	2	3	4	5	
RMS (mV)	410	37	125	58	65	
RMS (µBAR)	3100	2900	1000	460	520	
dB (a)	144	143	134	127	128	

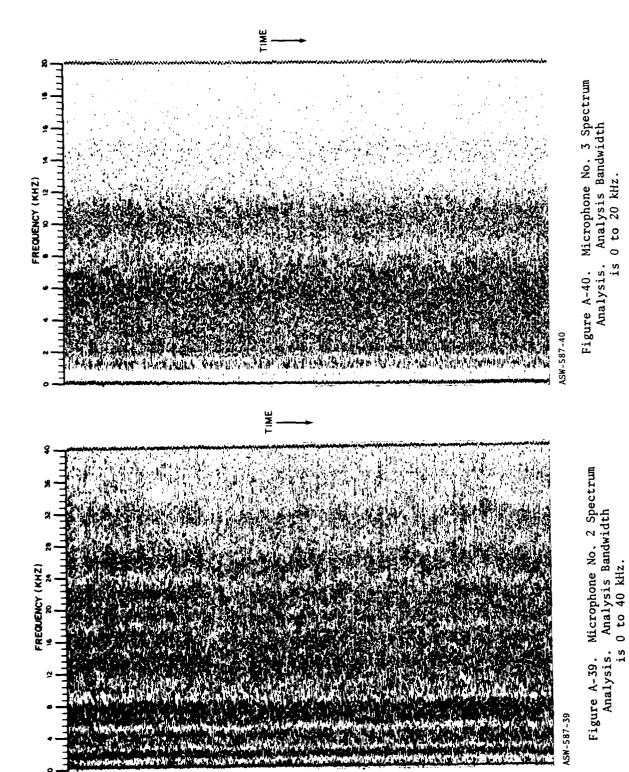
^aReference - 2 x 10⁻⁴ µBAR

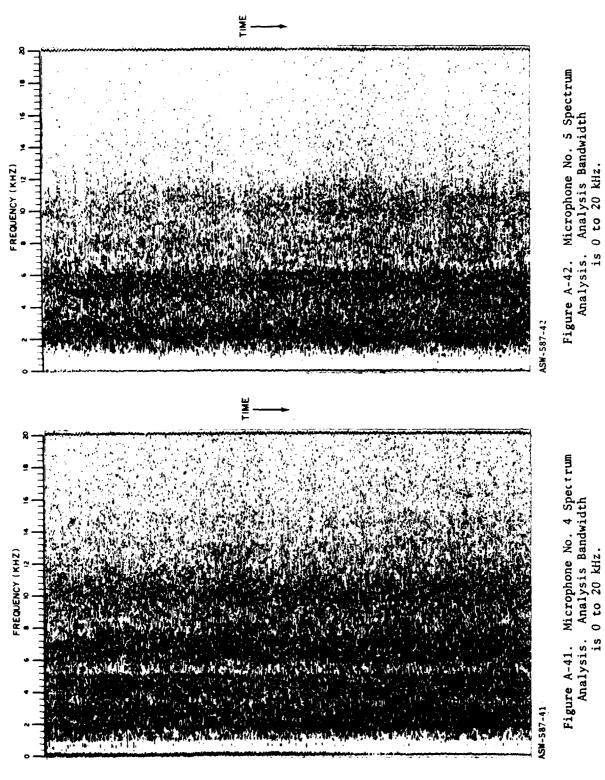
Table A-6. Microphone Sound Energy Levels at 90% Engine RPM

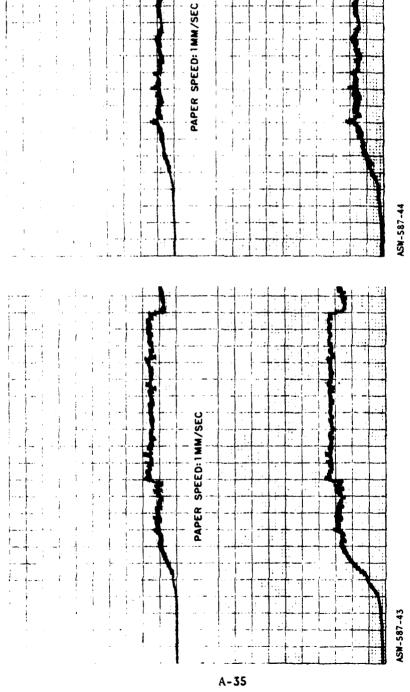
SOUND LEVEL	MI CROPHONE					
	1	2	3	4	5	
RMS (mV)	540	46	180	80	70	
RMS (µBAR)	4300	3600	1450	640	560	
dB (a)	147	145	137	130	129	

^aReference = $2 \times 10^{-4} \mu BAR$







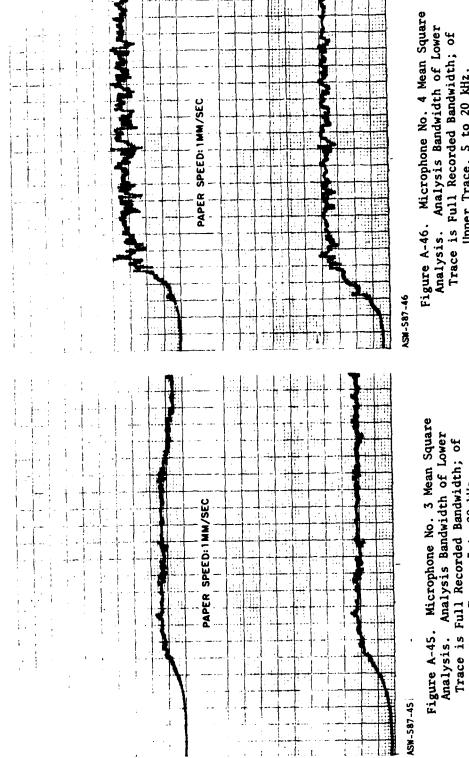


I P STJOV

Figure A-43. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

Figure A-44. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

\$TJOV



STJOY

0

Figure A-46. Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

Upper Trace, 5 to 20 kHz.

STJOV

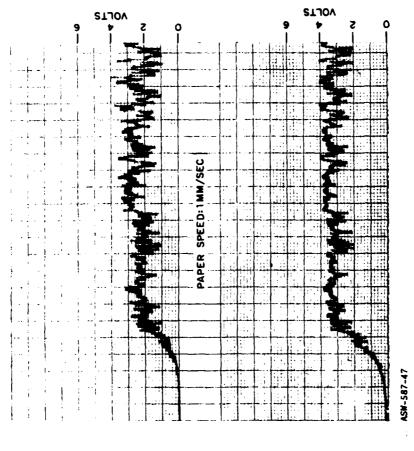


Figure A-47. Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

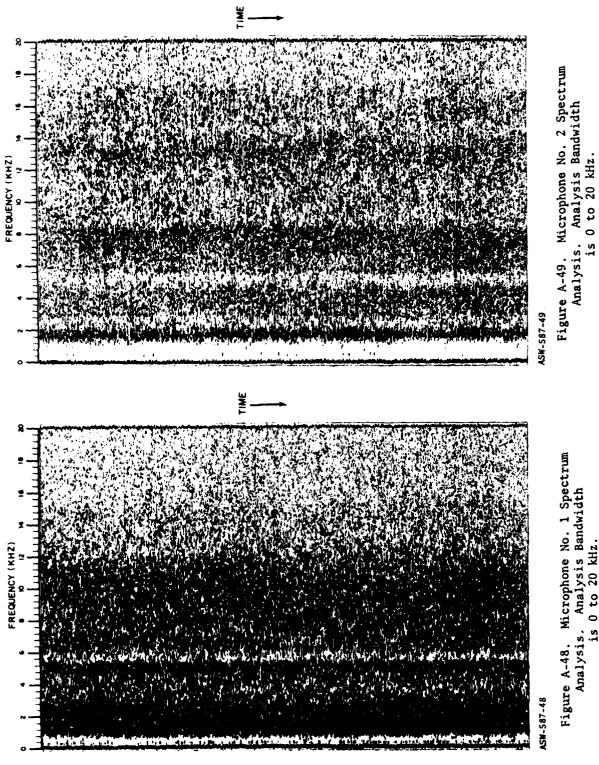
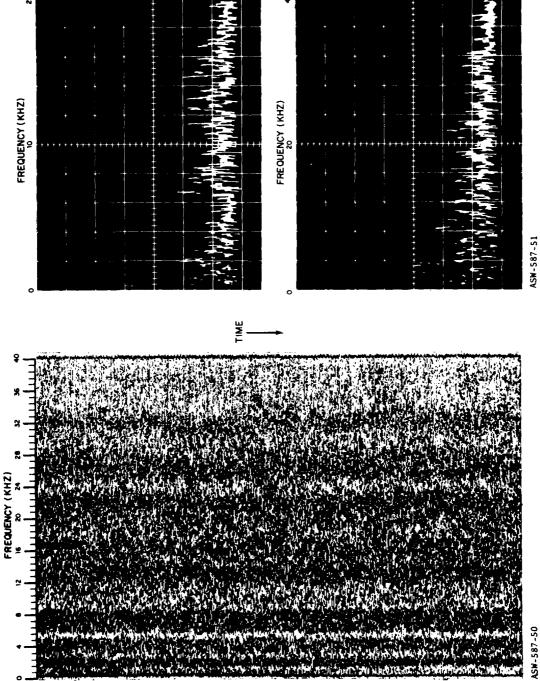


Figure A-48. Microphone No. 1 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



1

Figure A-51. Microphone No. 2 Spectrum Analysis. Analysis Bandwidths are 0 to 20 kHz and 0 to 40 kHz.

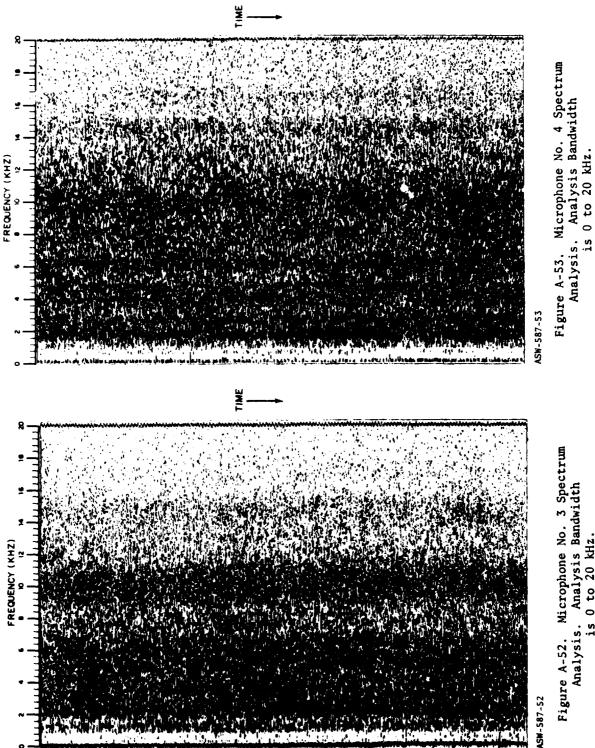


Figure A-52. Microphone No. 3 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

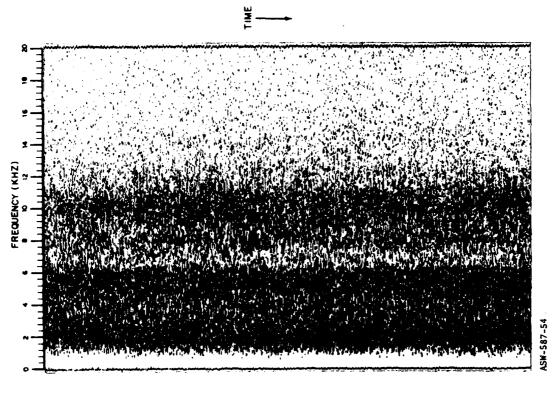


Figure A-54. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

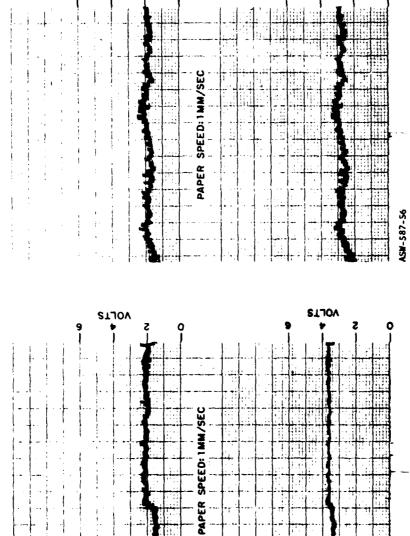
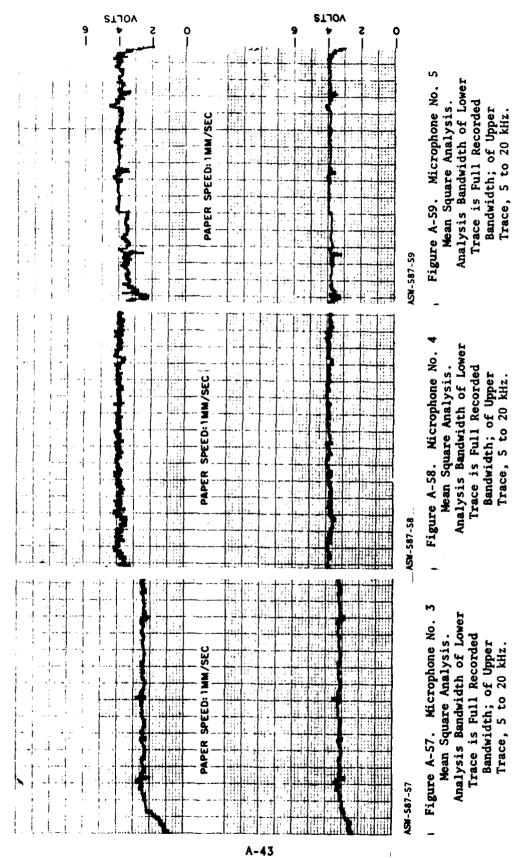


Figure A-55. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

ASN-587-55

Figure A-56. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of

Upper Trace, 5 to 20 kHz.



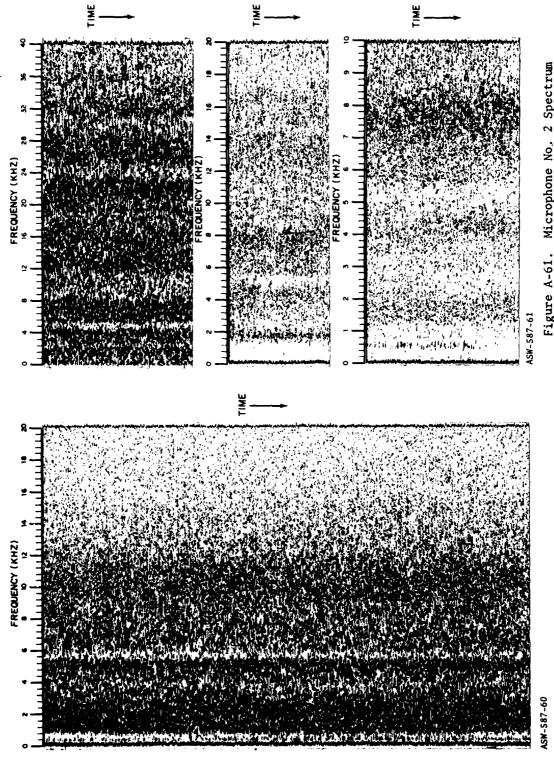


Figure A-61. Microphone No. 2 Spectrum Analysis. Analysis Bandwidths are 0 to 40 kHz, 0 to 20 kHz, and 0 to 10 kHz, respectively. Figure A-60. Microphone No. 1 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

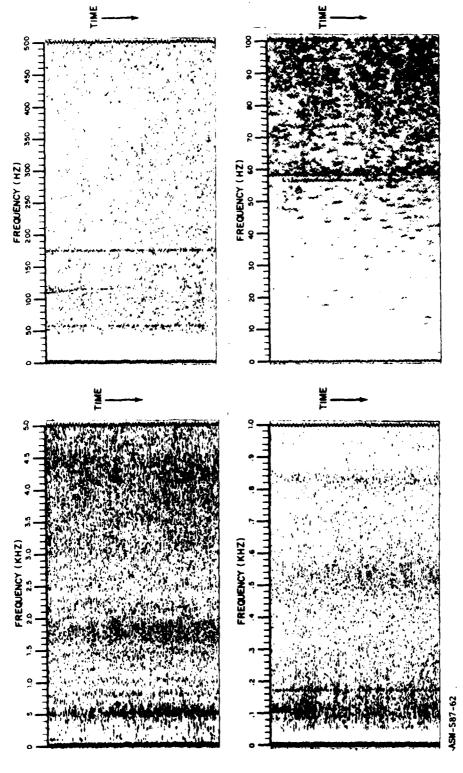
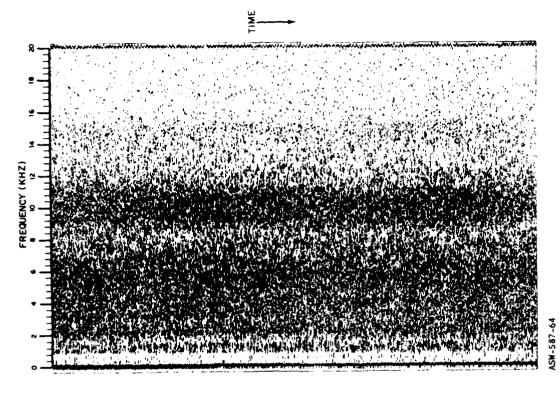
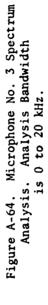


Figure A-62. Microphone No. 2 Spectrum Analysis. Analysis Bandwidths are 0 to 5 kHz, 0 to 1 kHz, 0 to 500 Hz, and 0 to 100 Hz, respectively.





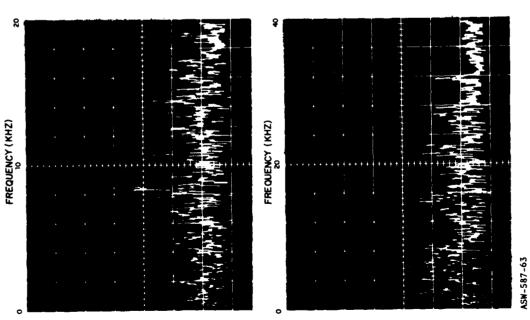


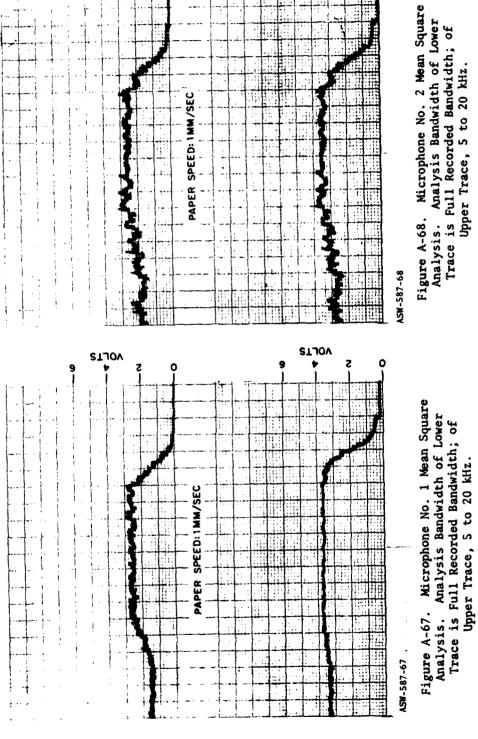
Figure A-63. Microphone No. 2 Spectrum Analysis. Analysis Bandwidths are 0 to 20 kHz and 0 to 40 kHz.

1

Figure A-65. Microphone No. 4 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

ASW-587-65

Figure A-66. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



YOLTS

٥

9

Figure A-68. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

STJOV

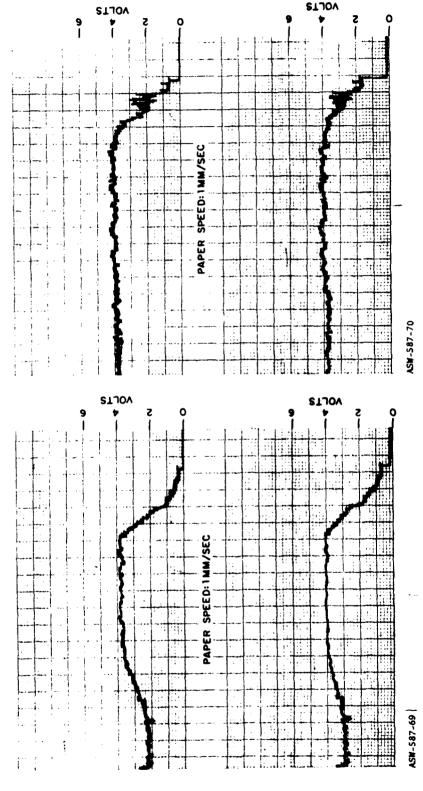


Figure A-69. Microphone No. 3 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

Figure A-70. Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

STJOV

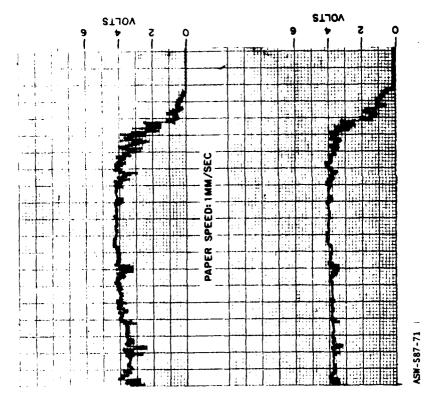


Figure A-71. Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

A.3 J-47 ENGINE, MODIFIED BURNER CAN HOLE OPEN - 1.0 INCH DIAMETER

A series of three test runs were made on the J-47 engine with the modified burner can hole masked to a 1.0-inch hole. Each test was recorded using five microphones located in the same positions as for the closed-hole tests. The three tests were run at the following engine speeds:

- (1) 70% RPM (46 in. Hg gage, diffuser case pressure)
- (2) 80% RPM (70 in. Hg gage, diffuser case pressure)
- (3) 90% RPM (97 in. Hg gage, diffuser case pressure)

The purpose of this test was to determine the sound energy level differential between a closed-hole on the modified burner can and a medium open hole (1.0 inch in diameter) at like engine speeds.

Analysis of the recordings made during the three runs is given on the following pages:

- (1) 70% run pages A-53 through A-58
- (2) 80% run pages A-59 through A-64
- (3) 90% run pages A-65 through A-70

A.3.1 Analysis

A.3.1.1 Sound Energy Levels

There was a decrease in the sound level of all microphones in this test as compared to the 1.5 inch open-hole test. The differences were more pronounced at low engine speed and less pronounced at high engine speed. The change was greatest in microphone 1, which was pointed directly at the open hole. Microphone 2, as in previous runs, approximated microphone 1 results. The 41% reduction in hole size area from 1.5 to 1.0 inch reduced the sound energy level an average of 20%.

A.3.1.2 Spectrum Analysis

The open-hole test results were similar to the 1.5 inch open-hole test results. All grams were less dense due to reduction in noise intensity. No other changes were apparent.

A.3.1.3 Mean Square Analysis

The results of this analysis were similar to the 1.5 inch openhole analysis with the exception that a greater portion of the spectrum was below 5 kHz. This was especially pronounced in microphones 1 and 4 and for all engine speeds.

A.3.2 Environmental Conditions

The three tests discussed in paragraph A.3 were performed at an ambient temperature of 61°F and 75% relative humidity.

A.3.3 Sound Energy Levels

The following tables list the sound energy levels of the five microphones at three engine test speeds:

Table A-7. Microphone Sound Energy Levels at 70% Engine RPM

	MI CROPHONE					
SOUND LEVEL	1	2	3	4	5	
RMS (mV)	140	15	50	20	17	
RMS (µBAR)	1100	1200	400	160	140	
dB (a)	135	135	126	118	117	

 $a_{\text{Reference}} = 2 \times 10^{-4} \text{ µBAR}$

Table A-8. Microphone Sound Energy Levels at 80% Engine RPM

SOUND LEVEL	MICROPHONE					
	1	2	3	4	5	
RMS (mV)	240	25	75	40	34	
RMS (µBAR)	1900	1950	600	320	280	
dB (a)	140	140	130	124	123	

 $a_{Reference} = 2 \times 10^{-4} \mu BAR$

Table A-9. Microphone Sound Energy Levels at 90% Engine RPM

SOUND LEVEL	MICROPHONE					
	1	2	3	4	5	
RMS (mV)	370	35	110	54	50	
RMS (µBAR)	3000	2800	880	430	400	
dB (a)	143	143	133	127	126	

Reference - 2 x 10⁻⁴ µBAR

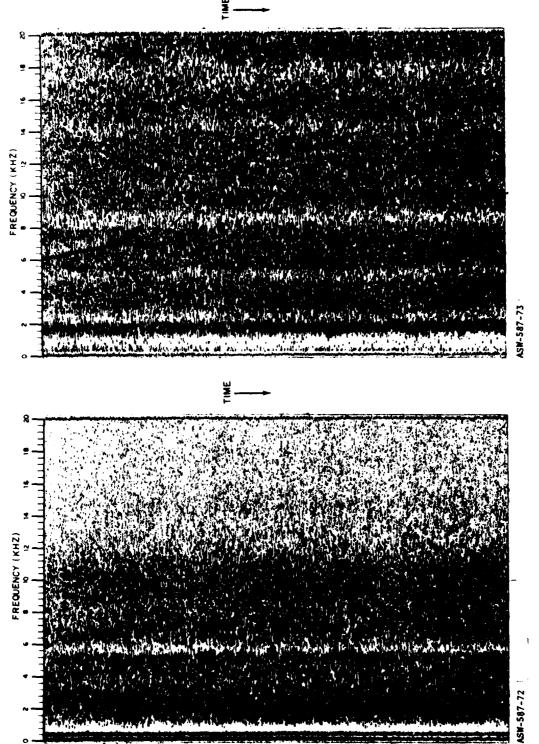


Figure A-72. Microphone No. 1 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

Figure A-73. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

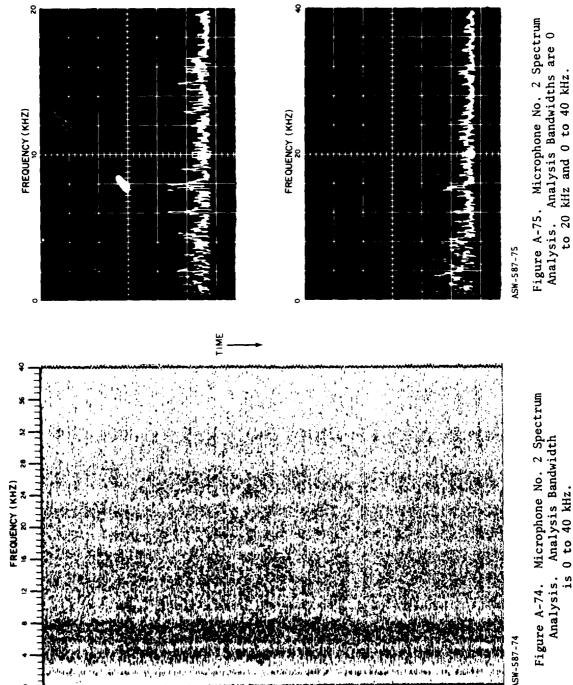


Figure A-74. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 40 kHz.

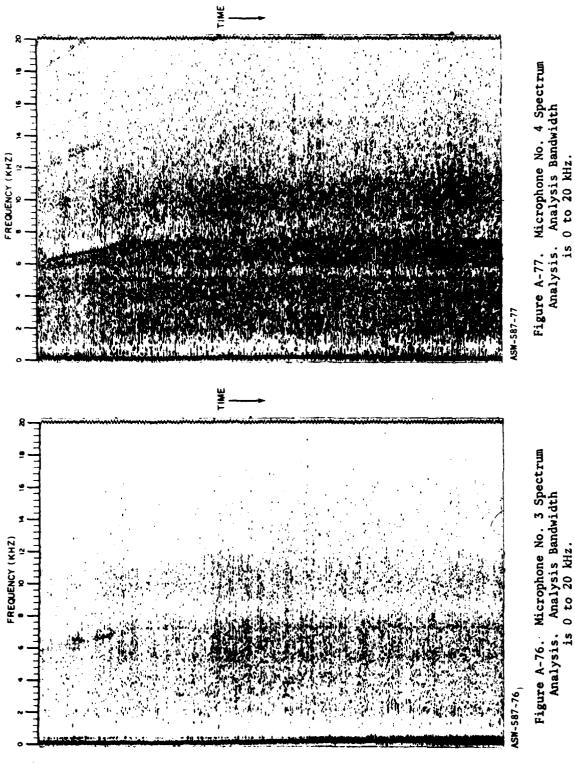


Figure A-77. Microphone No. 4 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

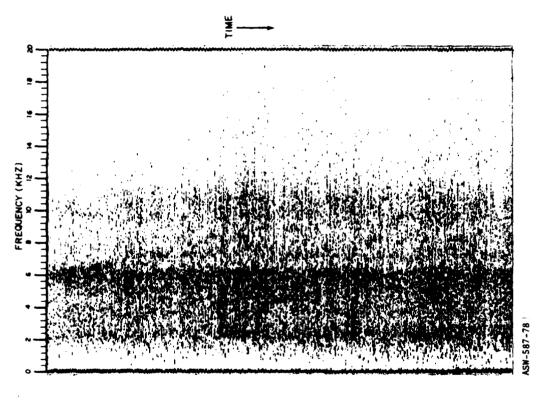


Figure A-78. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

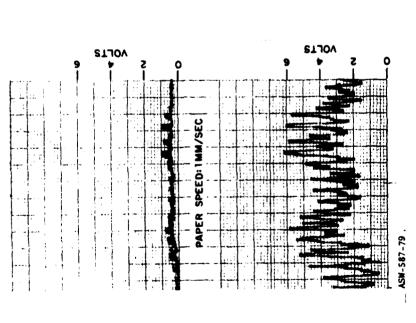


Figure A-79. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

The state of the s

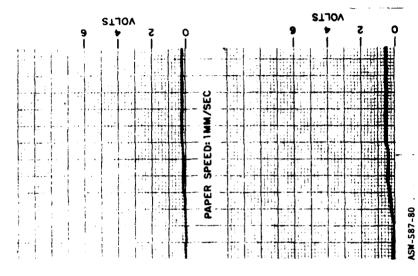


Figure A-80. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

Figure A-82. Microphone No. 'Mean Square Analysis.
Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

ASW-587-83
Figure A-83. Nicrophone No. 5
Mean Square Analysis.
Analysis Bandwidth of Lower
Trace is Full Recorded
Bandwidth; of Upper
Trace, 5 to 20 kHz.

0

0

Figure A-81. Microphone No. 3

ASM-587-81

Mean Square Analysis. Analysis Bandwidth of Lower

Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

THE RESERVE OF THE PARTY OF THE

STJOY

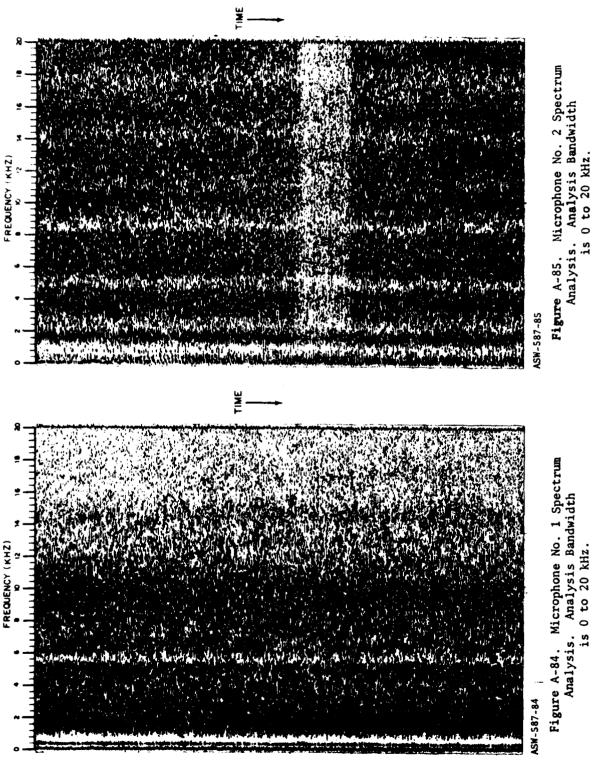
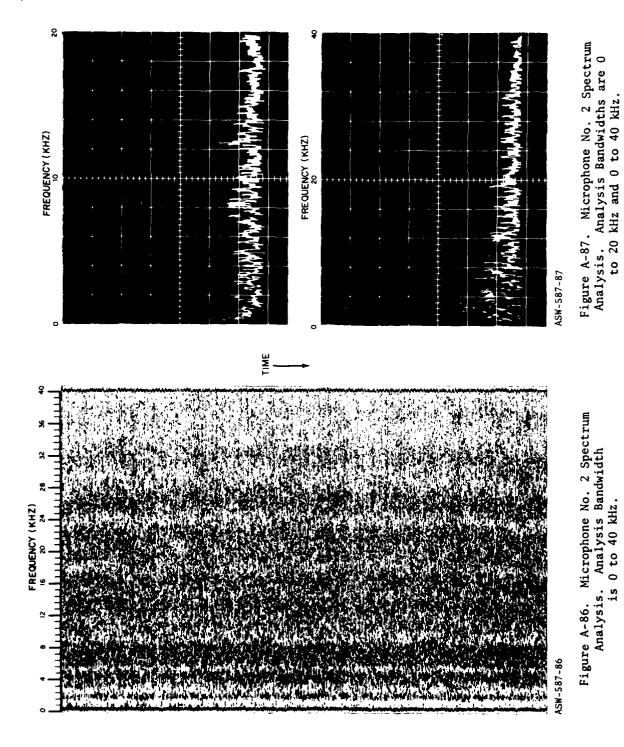


Figure A-85. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.





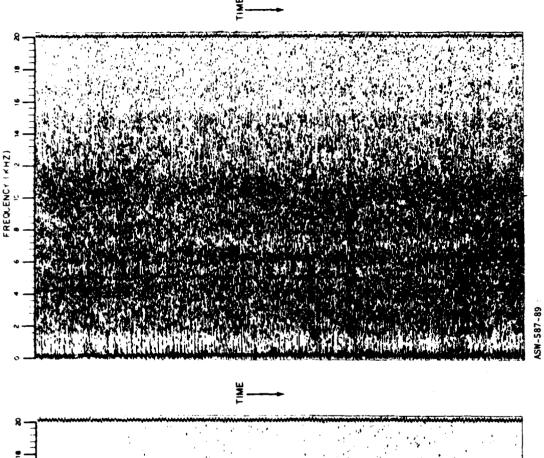


Figure A-88. Microphone No. 3 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

ASW-587-88

Figure A-89. Microphone No. 4 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

FREQUENCY (KHZ)

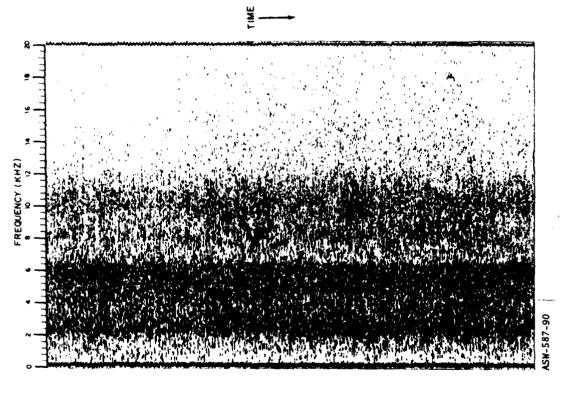
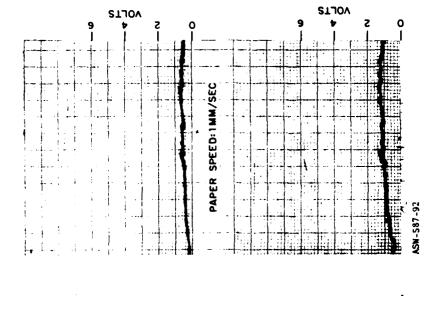
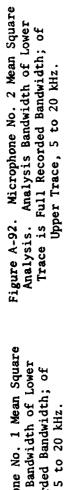


Figure A-90. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

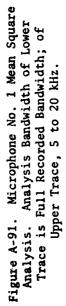


PAPER SPEED: 1MM/SEC

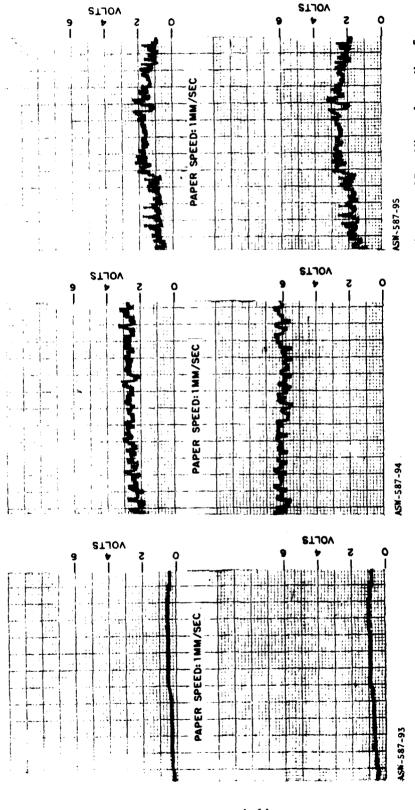
.



VOLTS



ASN-587-91



į

Analysis Bandwidth of Lower Trace is Full Recorded Figure A-94. Microphone No. Mean Square Analysis. Bandwidth; of Upper Trace, 5 to 20 kHz.

Figure A-93. Microphone No. 3

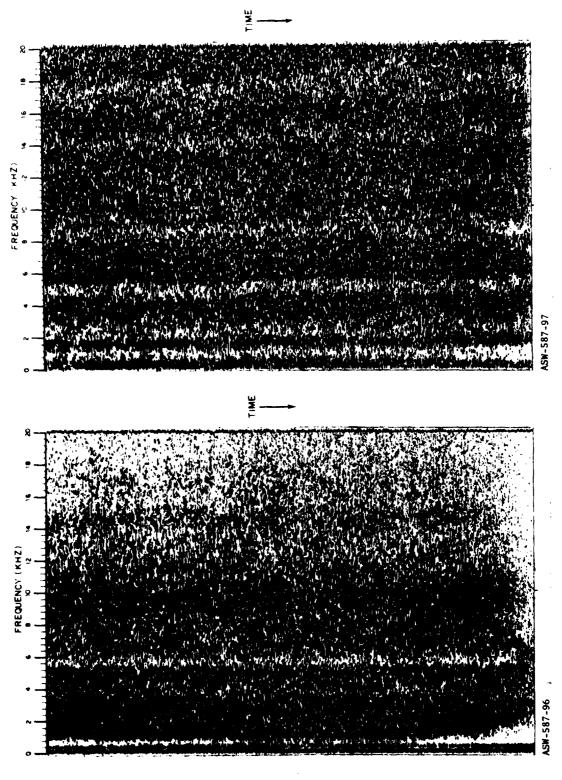
Analysis Bandwidth of Lower Mean Square Analysis.

Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

THE PROPERTY OF

Figure A-95. Microphone No. 5 Analysis Bandwidth of Lower Mean Square Analysis. Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

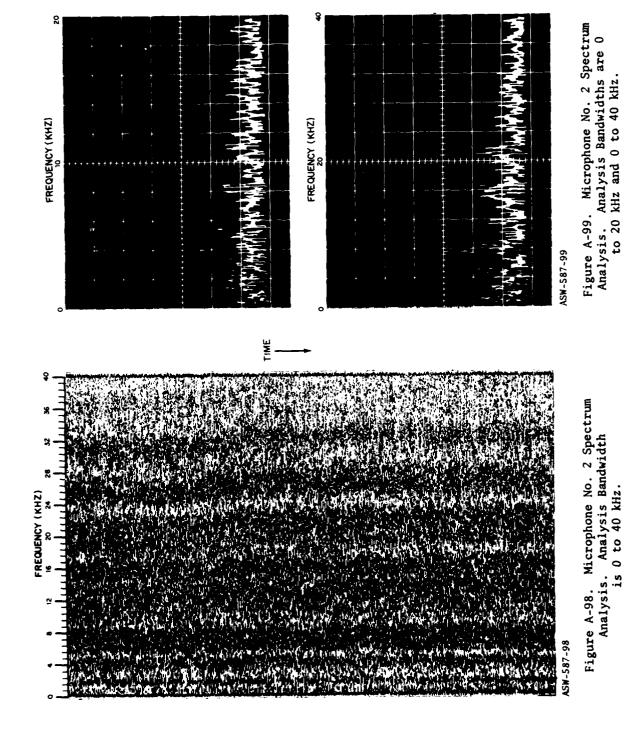
VOLTS

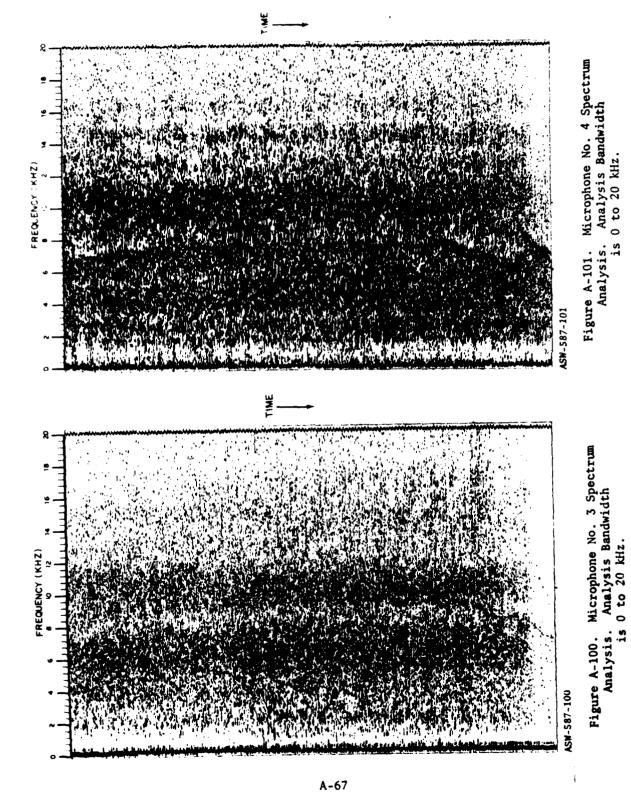


1

Figure A-97. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

Figure A-96. Microphone No. 1 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.





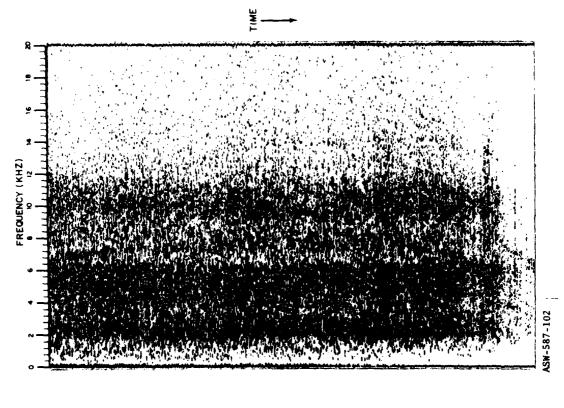
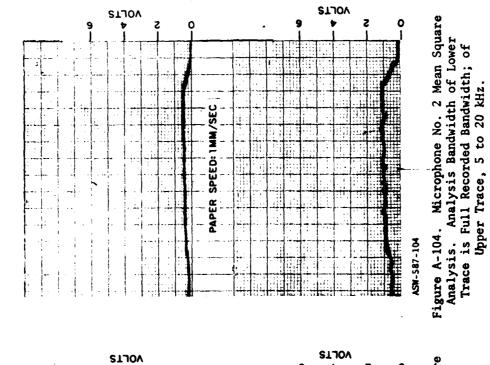


Figure A-102. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



SPEED: 1MM/SEC

PAPER

H

Figure A-103. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. ASM-587-103

The second secon

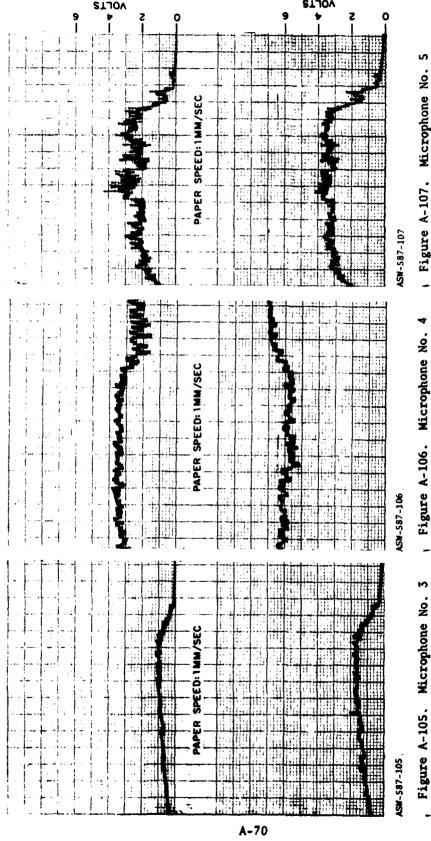


Figure A-106. Microphone No. 4
Mean Square Analysis.
Analysis Bandwidth of Lower
Trace is Full Recorded
Bandwidth; of Upper
Trace, S to 20 kHz.

Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded

Bandwidth; of Upper Trace, 5 to 20 kHz.

Aralysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

A.4 J-47 ENGINE, MODIFIED BURNER CAN HOLE OPEN - 0.75 INCH DIAMETER

A series of three test runs were made on the J-47 engine with the modified can hole masked to a 0.75-inch hole. Each test was recorded using five microphones located in the same positions as for the closed-hole tests. The three tests were run at the following engine speeds:

- (1) 70% RPM (46 in. Hg gage, diffuser case pressure)
- (2) 80% RPM (70 in. Hg gage, diffuser case pressure)
- (3) 90% RPM (97 in. Hg gage, diffuser case pressure)

The purpose of this test was to determine the sound energy level differential between a closed hole on the modified burner can and a small open hole (0.75 inch in diameter) at like engine speeds.

Analysis of the recordings made during the three runs is given on the following pages:

- (1) 70% run pages A-73 through A-75
- (2) 80% run pages A-79 through A-84
- (3) 90% run pages A-85 through A-90

A.4.1 Analysis

A.4.1.1 Sound Energy Levels

As in the 1.0 inch open-hole test, there was a decrease in the sound level of all microphones. The decrease, however, was more pronounced at high engine speeds than at low engine speeds. This is the direct opposite of the results of the 1.0 inch open hole test. The magnitude of change from a 1.5 to a 1.0-inch open hole and from a 1.0 to a 0.75-inch open hole was approximately equal. The reduction in 0.75 inch open hole area is approximately 55% of 1.0 inch open hole and 25% of 1.5 inch open hole.

A.4.1.2 Spectrum Analysis

The 0.75 inch open-hole test results were similar to the 1.0 inch open-hole test results. All grams were less dense due to a reduction in noise intensity. The changes were most pronounced in microphones 3 and 5.

A.4.1.3 Mean Square Analysis

The results of this analysis were similar to the 1.0 inch open-hole test. Again, microphone 1 and 4 recordings showed that a large portion of the spectrum was below 5 kHz.

THE PARTY OF THE P

A.4.2 Environmental Conditions

The three tests discussed in paragraph A.4 were performed at an ambient temperature of 61°F and 75% relative humidity.

A.4.3 Sound Energy Levels

The following tables list the sound energy levels of the five microphones at three engine test speeds:

Table A-10. Microphone Sound Energy Levels at 70% Engine RPM

	MICROPHONE				
SOUND LEVEL	1	2	3	4	5
RMS (mV)	90	8	28	15	13
RMS (µBAR)	720	630	260	120	105
dB (a)	131	130	121	116	114

aRef = 2 x 10^{-4} μ BAR

Table A-11. Microphone Sound Energy Levels at 80% Engine RPM

	MICROPHONE					
SOUND LEVEL	1	2	3	4	5	
RMS (mV)	170	19	45	26	20	
RMS (µBAR)	1350	1500	360	210	160	
dB (a)	136	137	125	120	118	

^aReference = $2 \times 10^{-4} \mu BAR$

Table A-12. Microphone Sound Energy Levels at 90% Engine RPM

	MICROPHONE				
SOUND LEVEL	1	2	3	4	5
RMS (mV)	240	26	61	33	32
RMS (µBAR)	1900	2000	490	260	250
dB (a)	139	140	128	122	122

^aReference = $2 \times 10^{-4} \mu BAR$

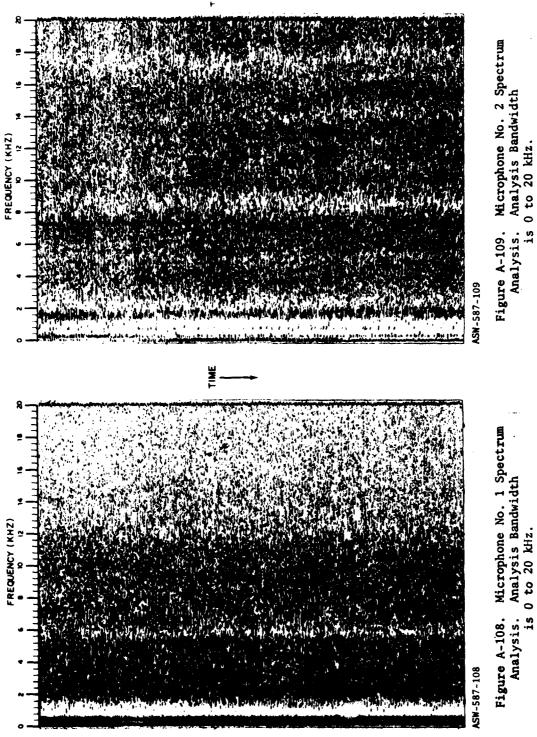


Figure A-109. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

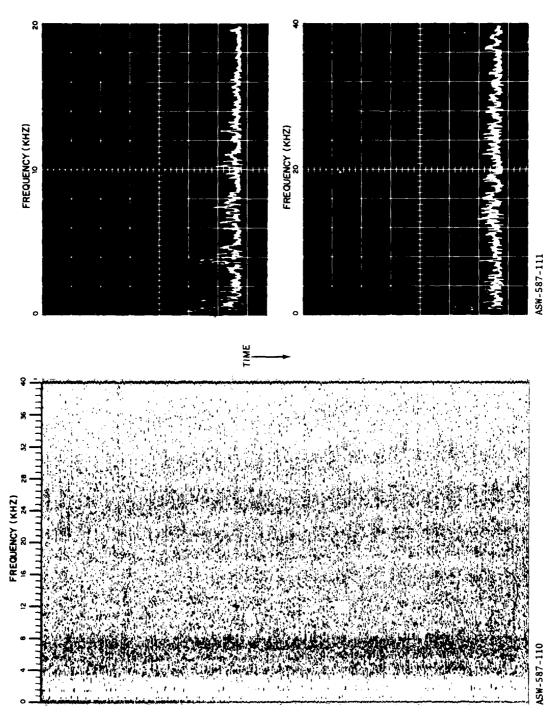
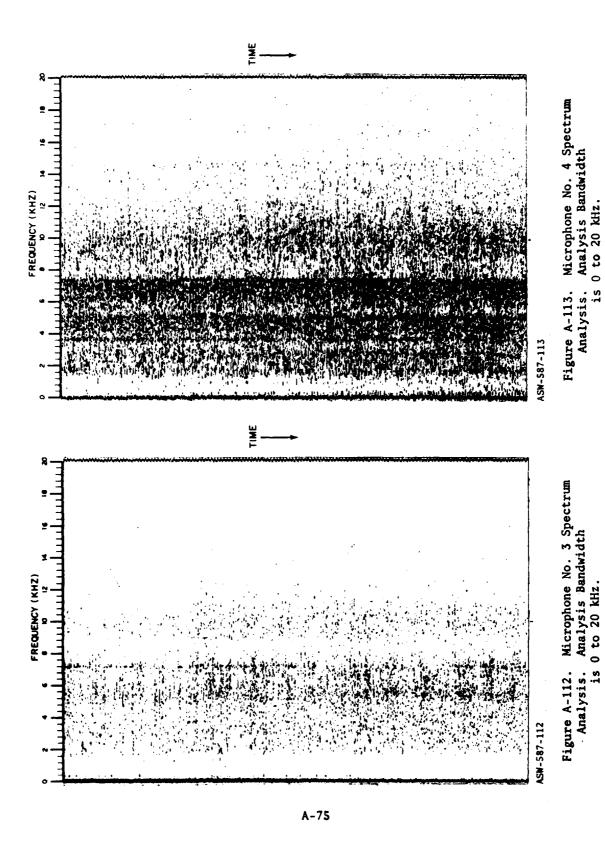


Figure A-110. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 40 kHz.

Figure A-111. Microphone No. 2 Spectrum Analysis. Analysis Bandwidths are 0 to 20 kHz and 0 to 40 kHz.



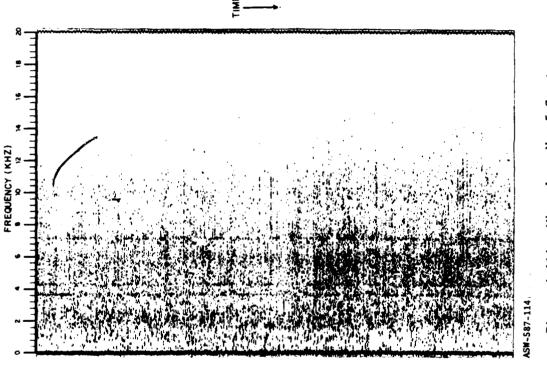
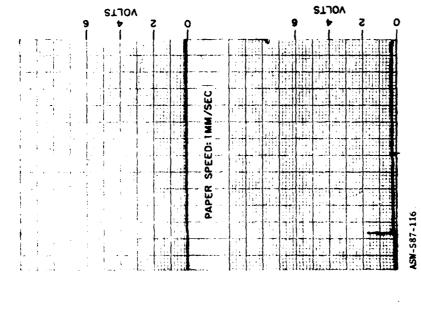


Figure A-114. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



Ò

PAPER SPEED: IMM/SEC

STJOY

Figure A-115. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

ASW-587-115

SITON

Figure A-116. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

PAPER SPEED: 1MM/SEC

PAPER SPEED: 1MM/SEC

ASM-587-119

Higure A-119. Microphone No.
Mean Square Analysis.
Analysis Bandwidth of Lower
Trace is Full Recorded
Bandwidth; of Upper
Trace, 5 to 20 kHz.

ASW-587-118

, Figure A-117. Microphone No. 3

ASM-587-117

Mean Square Analysis. Analysis Bandwidth of Lower

Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

, Figure A-118. Microphone No. 4
Mean Square Analysis.
Analysis Bandwidth of Lower
Trace is Full Recorded
Bandwidth; of Upper
Trace, 5 to 20 kHz.

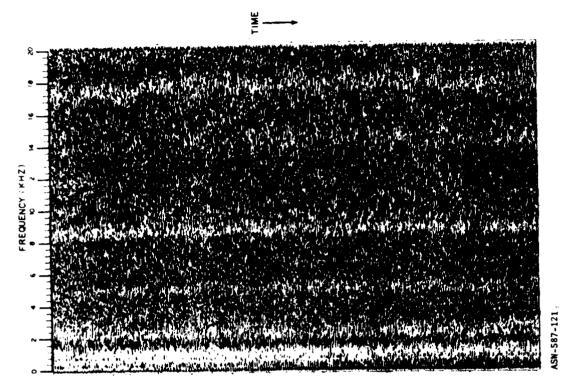
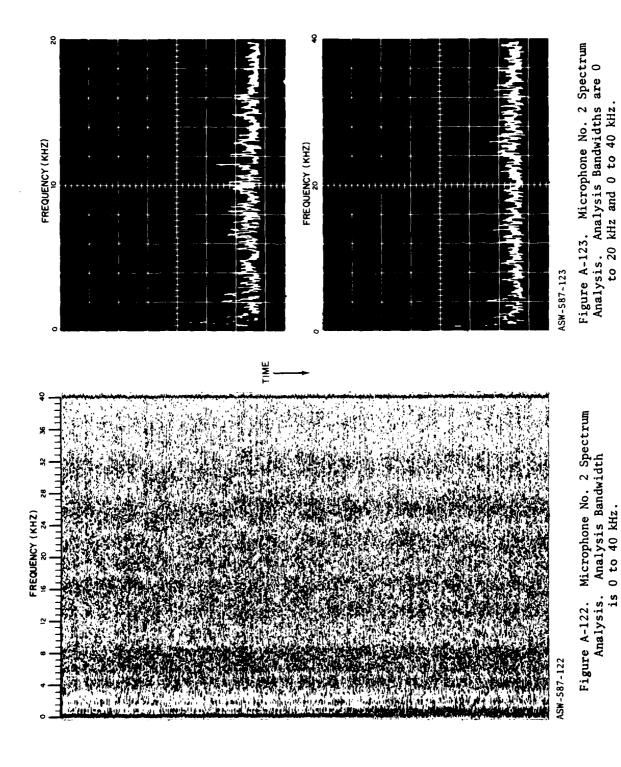


Figure A-120. Microphone No. 1 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

ASW-587-120

Figure A-121. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



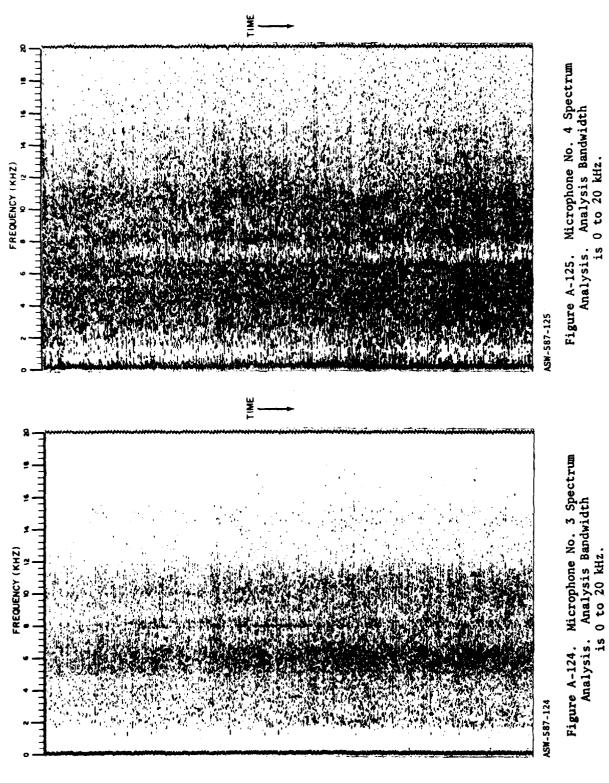


Figure A-125. Microphone No. 4 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

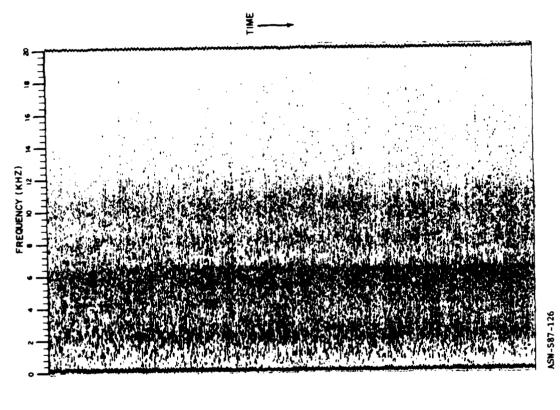


Figure A-126. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

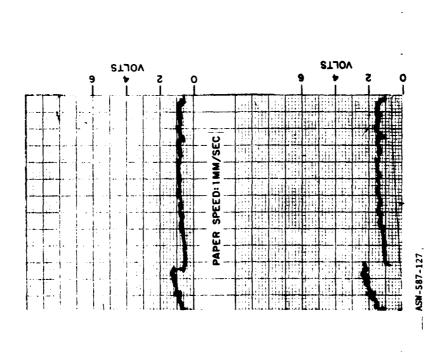


Figure A-127. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

The second secon

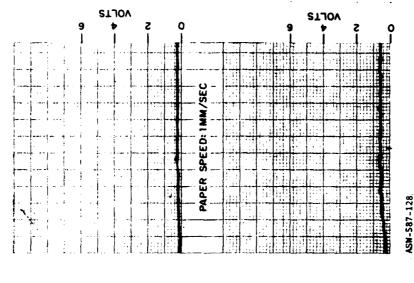


Figure A-128. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

VOLTS

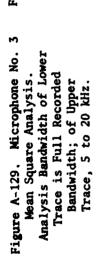


Figure A-130. Microphone No. 4 Figure A-13
Mean Square Analysis.
Analysis Bandwidth of Lower Analysis
Trace is Full Recorded Trace i
Bandwidth; of Upper Bandw
Trace, 5 to 20 kHz.

Figure A-131. Microphone No. 5
Mean Square Analysis.
Analysis Bandwidth of Lower
Trace is Full Recorded
Bandwidth; of Upper
Trace, 5 to 20 kHz.

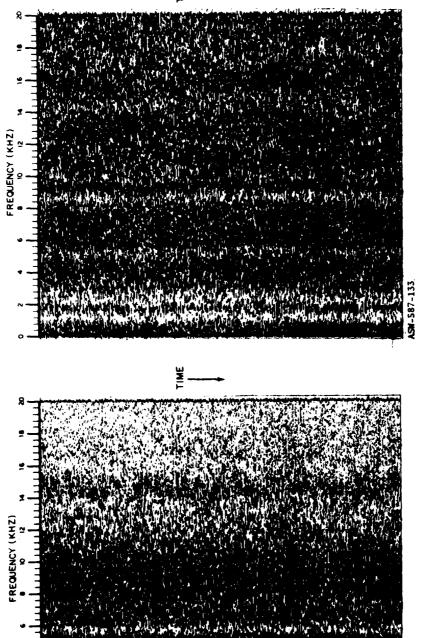


Figure A-132. Microphone No. 1 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

ASM-587-132

Figure A-133. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

)

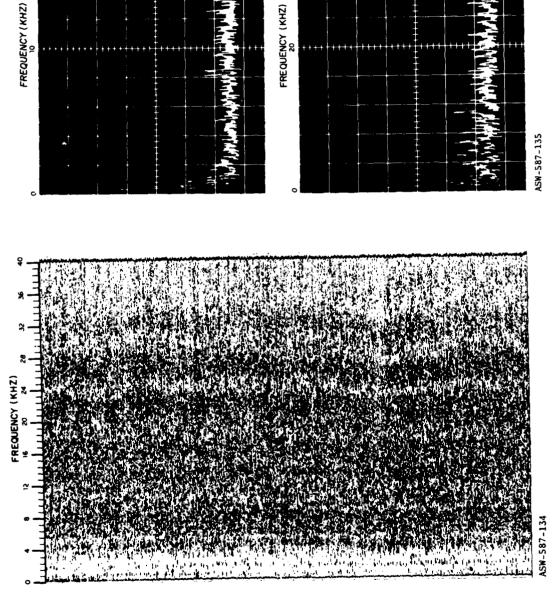


Figure A-135. Microphone No. 2 Spectrum Analysis. Analysis Bandwidths are 0 to 20 kHz and 0 to 40 kHz.

Figure A-134. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 40 kHz.

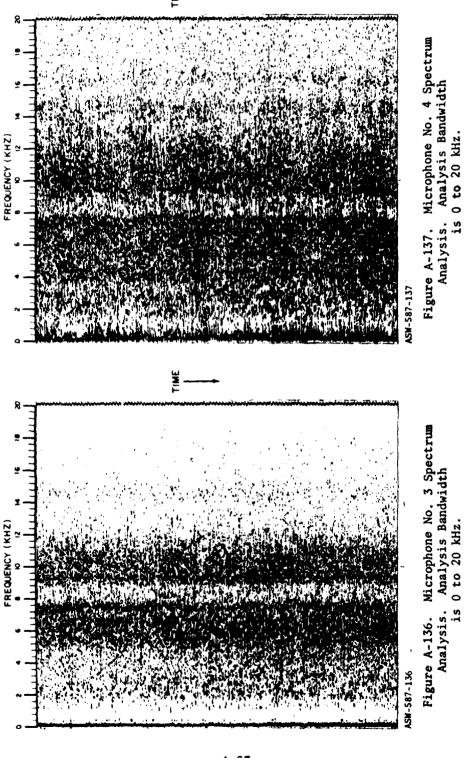


Figure A-136. Microphone No. 3 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

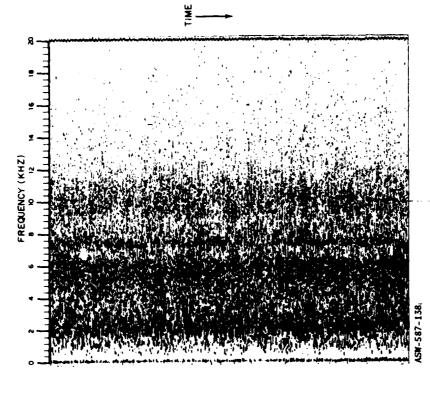
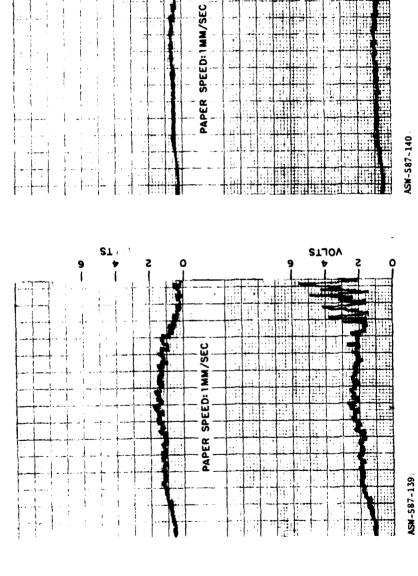


Figure A-138. Micraphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



| VOLTS

0

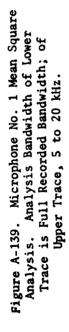
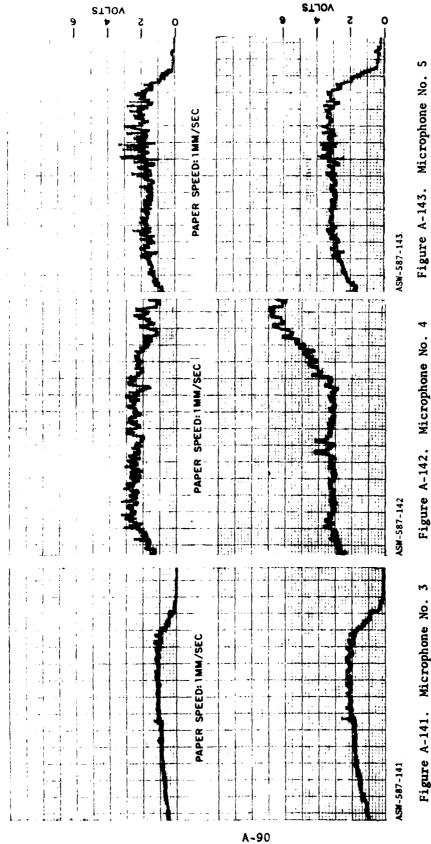


Figure A-140. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

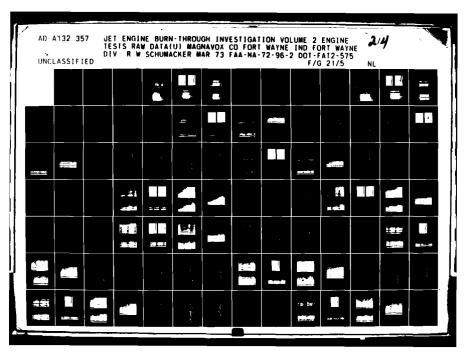
STJOV

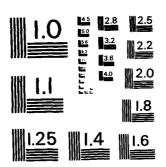


Analysis Bandwidth of Lower Mean Square Analysis. Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

Analysis Bandwidth of Lower Mean Square Analysis. Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS - 1963 - A

A.5 J-47 ENGINE, MODIFIED BURNER CAN FAILURE No. 1

In order to simulate an actual burner can burn-through, the open hole in the modified burner can on the J-47 engine was masked to a 1.5-inch diameter hole and covered with a 0.1-inch thick lead cap. Lead, with its low melting point, was used to facilitate rapid failure since this engine lacked the power and consequently the heat to burn through a thicker or higher melting point material. The engine was started and power was increased with flame in the can until failure occurred. The test was recorded using five microphones located in the same positions as for the closed hole test. The purpose of this test was to compare the sound energy level of a burn-through with that of an open hole.

Analysis of the recordings made during this test run appear on pages A-93 through A-97.

A.5.1 Analysis

A.5.1.1 Sound Energy Level

The burn-through test resulted in a reading of 121 dB prior to burn-through and 143 dB after burn-through. Readings were taken on microphone No. 1 only, since the lead hole cover melted too rapidly to allow for readings on other microphones. The results compared favorably with microphone No. 1 results for the closed hole test at 80% RPM and the 1.5 inch open hole test at 80% RPM.

A.5.1.2 Spectrum Analysis

The results of the spectrum analysis indicated that the lead plate failed when engine speed was slightly more than 80% RPM. This was determined by comparing discrete machinery frequencies on grams from previous runs to the grams of the burn-through. No discrete frequencies due to the burn-through were apparent. The microphone No. 2 gram was of little value because of an intermittent cable.

A.5.1.3 Mean Square Analysis

The burn-through was most pronounced on the microphone 4 and 5 recordings. The microphone 4 recording again showed a quantity of the spectrum below 5 kHz. This was especially pronounced prior to burn-through.

A.5.2 Environmental Conditions

The test was performed at an ambient temperature of 77° F and 90% relative humidity.

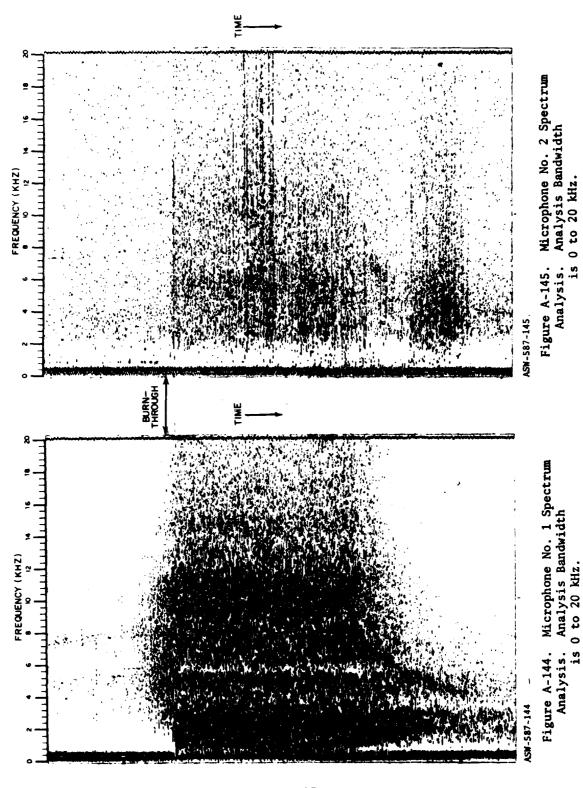
A.5.3 Sound Energy Level

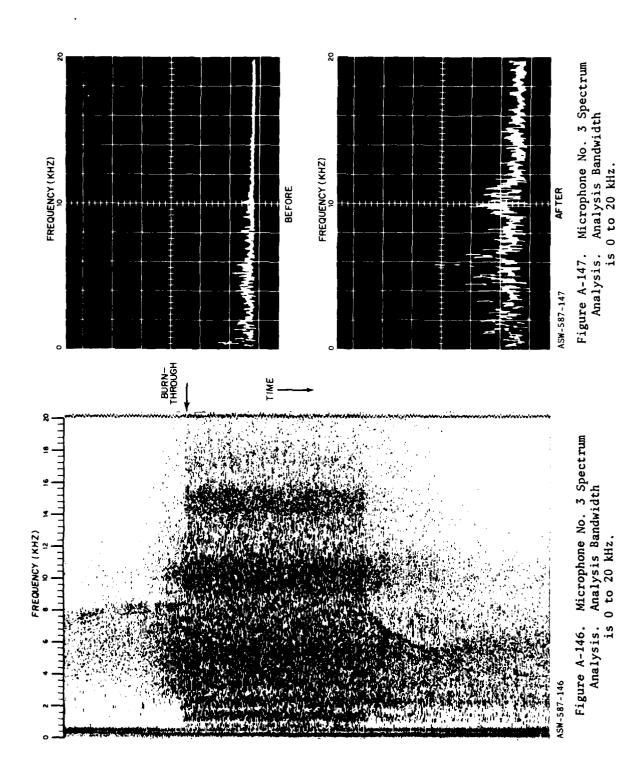
The following table lists the sound energy level of microphone no. 2 before and after burn-through.

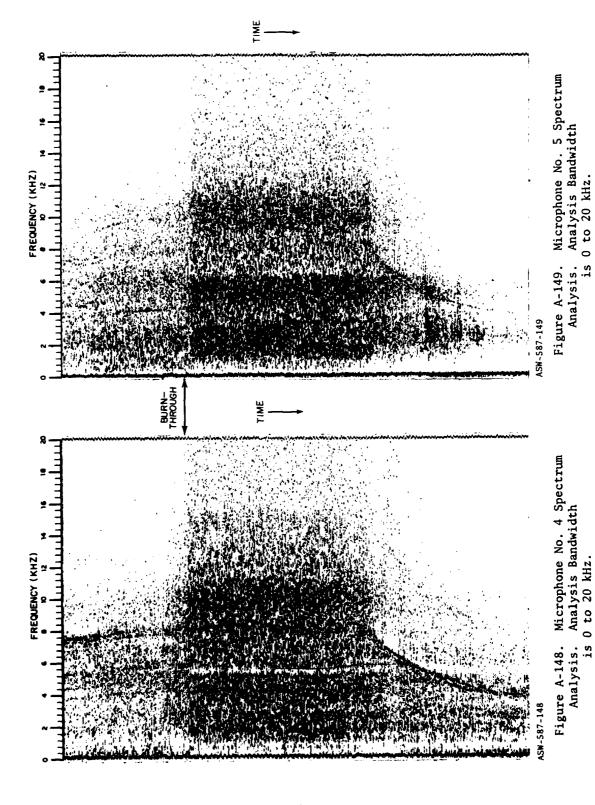
Table A-13. Sound Energy Level Before and After Burn-through

	MICROPHONE No.2			
SOUND LEVEL	BEFORE	AFTER		
RMS (mV)	28	370		
RMS (µBAR)	230	3000		
dB (a)	121	143		

^aReference = $2 \times 10^{-4} \mu BAR$







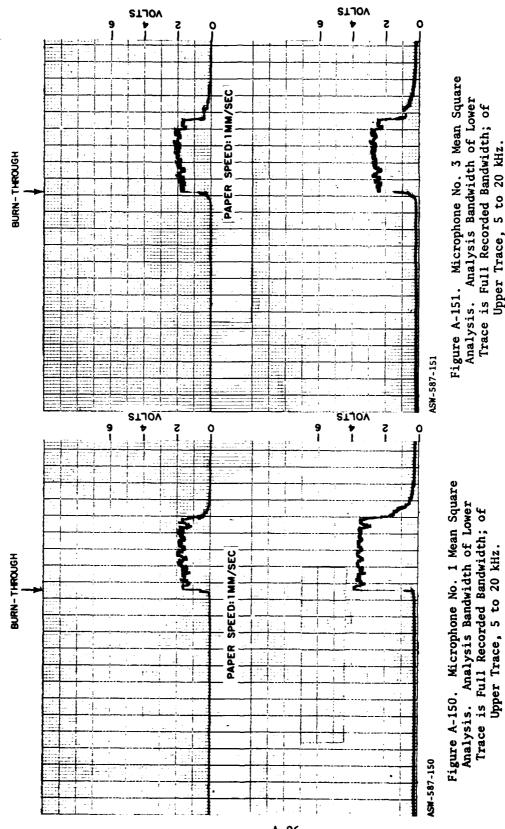


Figure A-151. Microphone No. 3 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

The state of the s

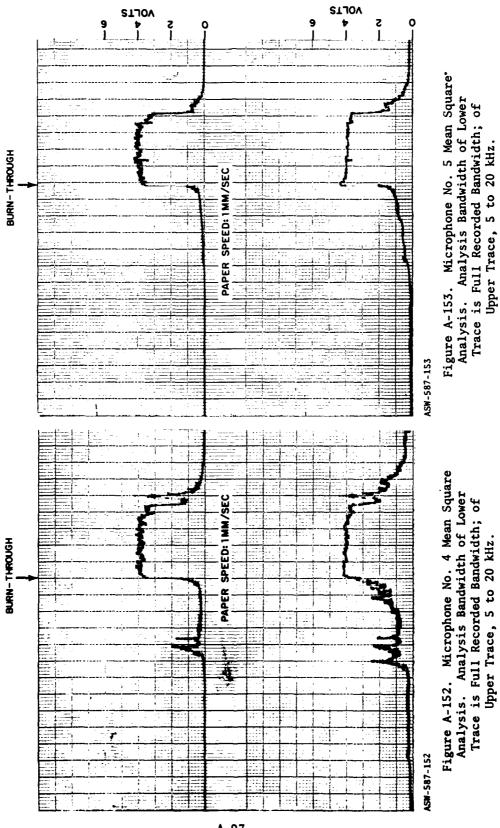


Figure A-153. Microphone No. 5 Mean Square. Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

A.6 J-47 ENGINE, MODIFIED BURNER CAN FAILURE No. 2

A second test was run, which duplicated the previous burner-can failure, on the J-47 engine.

Analysis of the recordings made during this test run appear on pages A-100 through A-104.

A.6.1 Analysis

A.6.1.1 Sound Energy Level

The second burn-through test resulted in a reading of 116 dB prior to burn-through and 134 dB after burn-through. Meter readings were from microphone No. 4 only for this test. When compared with closed hole and 1.5 inch open-hole test readings, readings from this test indicated that engine speed prior to burn-through was slightly greater than 70% and after burn-through slightly greater than 80%.

A.6.1.2 Spectrum Analysis

The results of the spectrum analysis did not show any discrete frequencies due to burn-through. By comparing the discrete frequencies of the machinery, it was determined that the burn-through occurred at 80% RPM. The microphone No. 2 gram was again of little value because of an intermittent cable.

A.6.1.3 Mean Square Analysis

Microphones 4 and 5 had the most pronounced change in energy levels. The microphone No. 3 recording repeated burn-through No. 1 results in that there was a large portion of low frequency components prior to burn-through.

A.6.2 Environmental Conditions

The test was performed at an ambient temperature of 77° F and 40% relative humidity.

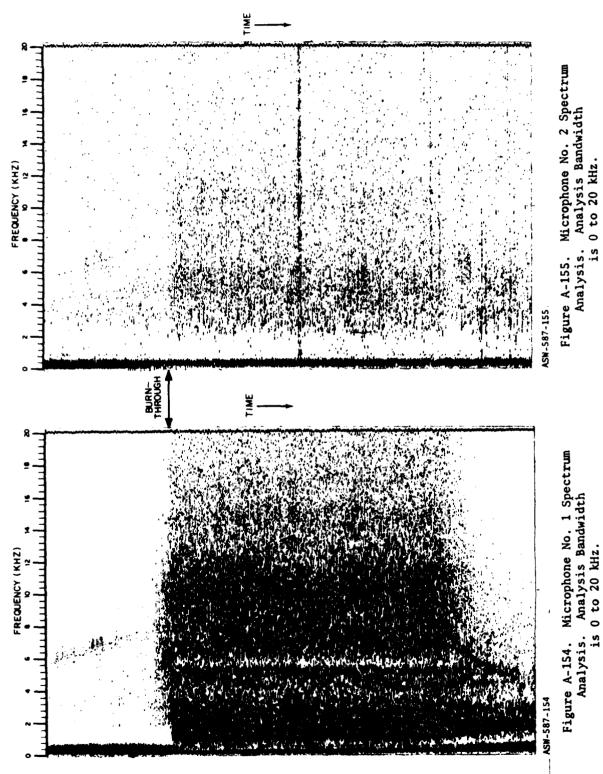
A.6.3 Sound Energy Level

The following table lists the sound energy level of microphone No. 3 before and after burn-through.

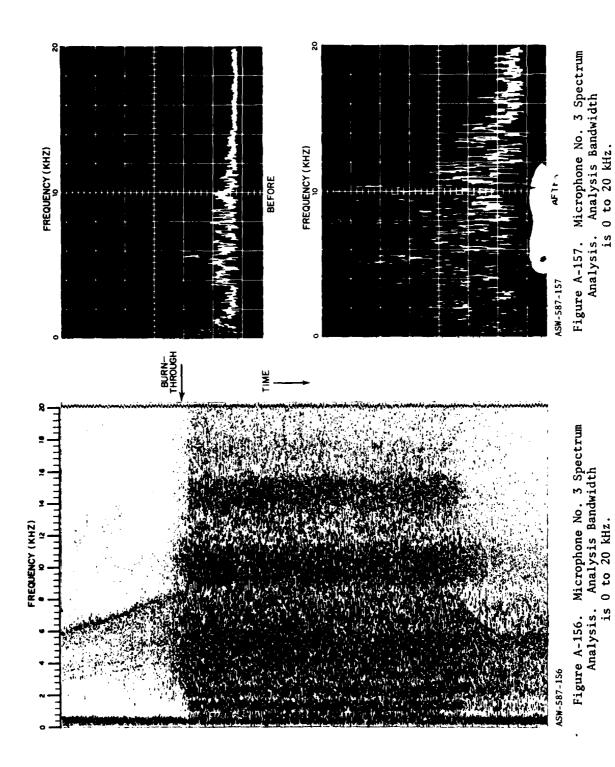
Table A-14. Sound Energy Level Before and After Burn-Through

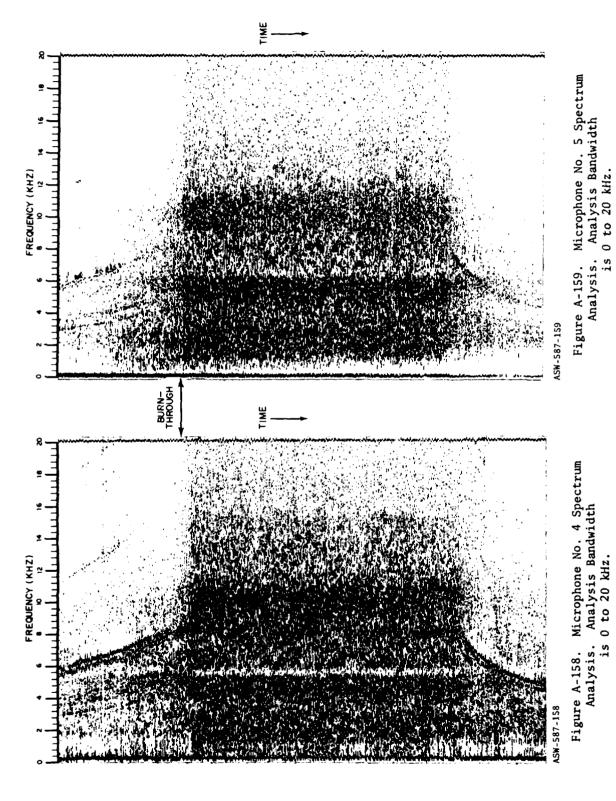
	MICROPHONE No. 3			
SOUND LEVEL	BEFORE	AFTER		
RMS (mV)	15	130		
RMS (µBAR)	120	1050		
dB (a)	116	134		

^aReference = $2 \times 10^{-4} \mu BAR$

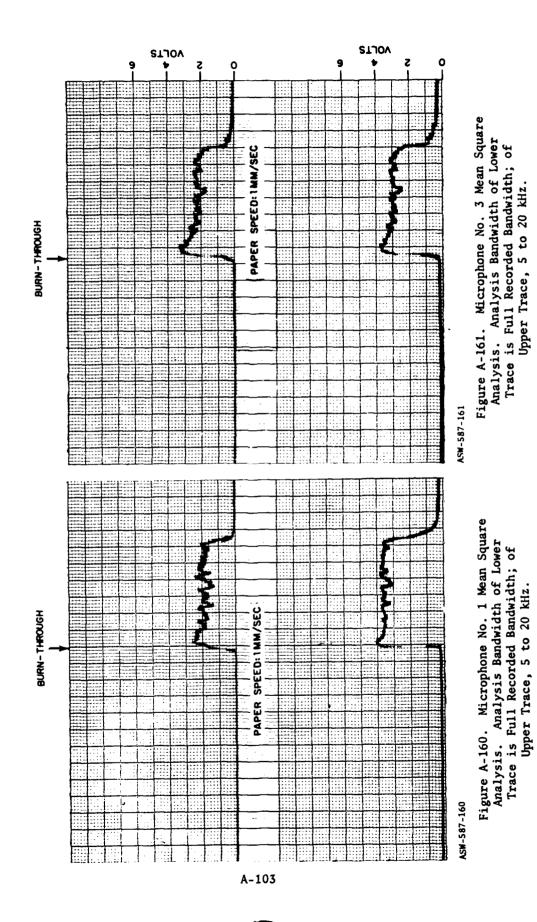


A-100





A-102



4

_. 1

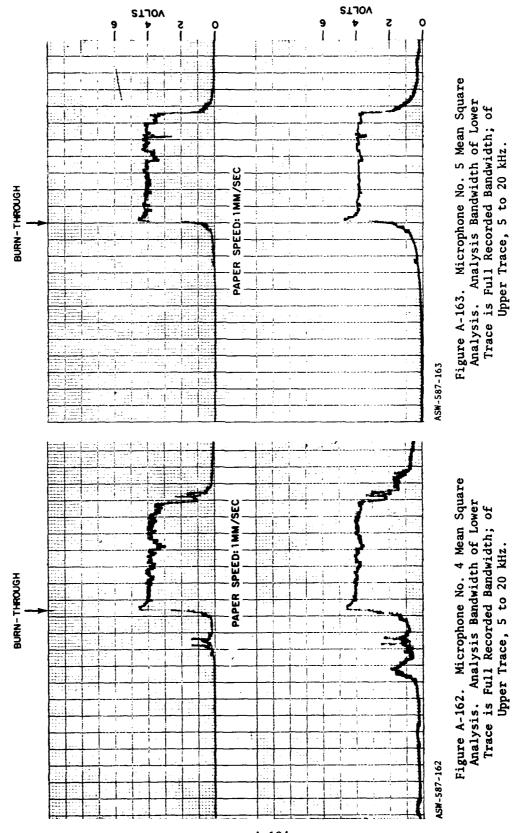


Figure A-163. Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

A-104

APPENDIX B

J-57 ENGINE (PORT)

B.1 J-57 ENGINE (PORT), MODIFIED BURNER CAN HOLE COVERED

A series of three test runs were made on the J-57 port engine with the modified burner can hole covered. Each test was recorded using five microphones placed as noted in the text. The three tests were run at the following engine speeds:

- (1) 82% RPM (150 in. Hg gage, diffuser case pressure)
- (2) 90% RPM (240 in. Hg gage, diffuser case pressure)
- (3) Max. RPM (270 in. Hg gage, diffuser case pressure)

The purpose of this test was to establish a reference to compare modified burner can closed hole sound energy levels at the three engine speeds with sound energy levels of the modified burner can with three sizes of open holes (1.5, 1.0, and 0.75 inch) at like engine speeds.

Analysis of the recordings made during the three runs is given on the following pages:

- (1) 82% run pages B-4 through B-10
- (2) 90% run pages B-11 through B-19
- (3) Max. run pages B-20 through B-26

B.1.1 Analysis

B.1.1.1 Sound Energy Levels

Output levels of microphones 1 through 5 were measured for RMS sound energy during each test run. Microphone 2 was a broadband instrumentation microphone and microphones 1, 3, 4, and 5 had a lower frequency response and were all of the same type. The data was converted to decibels by conversion factors detailed in Appendix F. Variations in RMS levels of microphones 1, 3, 4, and 5 are attributed to microphone location and proximity to engine machinery (i.e., fuel pumps, etc.).

The closed-hole test measurements are representative of a normal engine. These measurements will be used as a reference to compare sound energy levels made during open hole tests which are representative of a burner can failure. Microphone sound levels decreased from the 82% RPM run to the 90% RPM run. This was due to strong discrete frequencies generated by engine machinery at 82% RPM. The frequencies appeared to be resonant at 82% RPM and to have several harmonics. The resonances dissipated as the engine speed was increased

to 90% RPM. The sound energy levels likewise decreased. Only a small change (1 dB) was noted between the 90% RPM run and the maximum RPM run.

B.1.1.2 Spectrum Analysis

The analysis bandwidth was 0 to 20 kHz for all microphones. In addition, the instrumentation microphone (No. 2) data was analyzed from 0 to 40 kHz. Discrete spectral content was especially evident in the 82% RPM run and most prominent in microphone 1, 2, and 4 grams, all of which were located farthest from the engine accessary drive machinery (fuel pump, oil pump, etc.). Microphone 3 and 5 grams showed less discrete frequencies and more broadband random noise. The 90% and maximum RPM grams were similar, and consisted primarily of broadband random noise with some machinery-created discrete frequency lines. The instrumentation microphone gram showed little noise above 20 kHz.

3.1.1.3 Mean Square Analysis

The data from each microphone was analyzed over bandwidths of 0 to 20 kHz and 5 to 20 kHz simultaneously, using mean square techniques. This method of analysis, when recorded, showed the summation of the total spectrum at any given time versus the summation of the spectrum above 5 kHz. The recordings showed considerable fluctuation at 82% RPM with most of the spectrum below 5 kHz. The recordings smoothed out at 90% and maximum RPM, but again most of the spectrum was below 5 kHz.

B.1.2 Environmental Conditions

The three tests discussed in paragraph B.1 were performed at an ambient temperature of 77° F and 25% relative humidity. Microphone temperatures were as follows:

	[MI CROPHONE					
	1	1 2 3 4 5					
TEMPERATURE (° F)	130	140	80 (a)	140	80 (a)		

^aThe thermocouples were inaccurate below 100° F.

B.1.3 Sound Energy Levels

The following tables list the sound energy levels of the five microphones at three engine test speeds:

Table B-1. Microphone Sound Energy Levels at 82% Engine RPM

			MICROPHONE		
SOUND LEVEL	1	2	3	4	5
RMS (mV)	100	39	49	72	37
RMS (µBAR)	800	3100	400	570	300
dB (a)	132	144	126	129	123

^aReference = $2 \times 10^{-4} \mu BAR$

Table B-2. Microphone Sound Energy Levels at 90% Engine RPM

	MICROPHONE				
SOUND LEVEL	1	2	3	4	5
RMS (mV)	40	13	31	30	40
RMS (µBAR)	320	1000	250	240	320
dB (a)	124	134	122	122	124

 a Reference = 2 x 10^{-4} µBAR

Table B-3. Microphone Sound Energy Levels at Maximum Engine RPM

			MICROPHONE		
SOUND LEVEL	1	_2	3	4	5
RMS (mV)	45	14	34	33	42
RMS (µBAR)	360	1100	270	260	340
dB (a)	125	135	123	122	125

^aReference = $2 \times 10^{-4} \mu BAR$

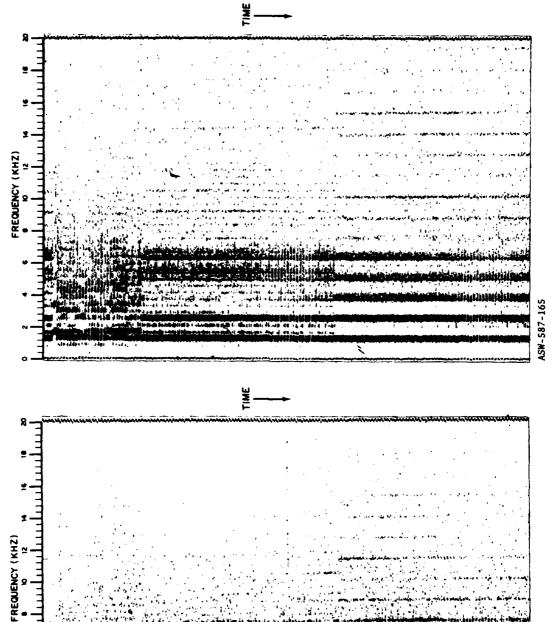


Figure B-1. Microphone No. 1 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

ASW-587-164

Figure B-2. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

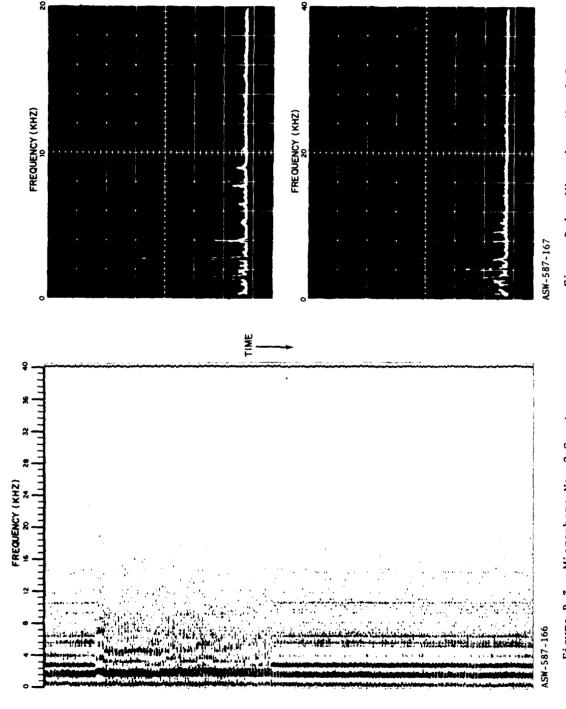


Figure B-4. Microphone No. 2 Spectrum Analysis. Analysis Bandwidths are 0 to 20 kHz and 0 to 40 kHz. Figure B-3. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 40 kHz.

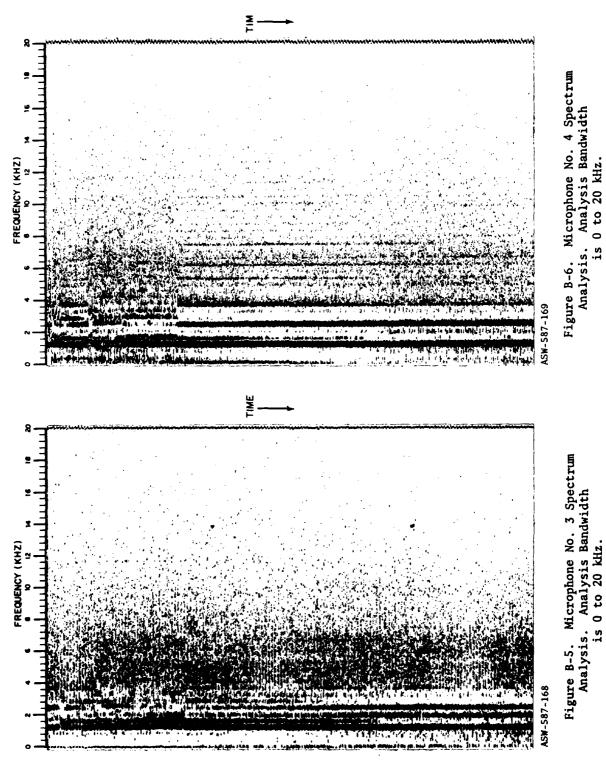
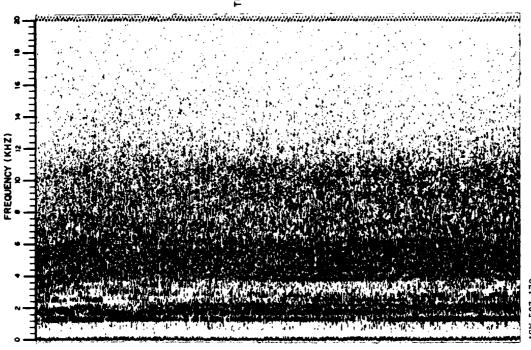


Figure B-5. Microphone No. 3 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.





SW-587-170

Figure B-7. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

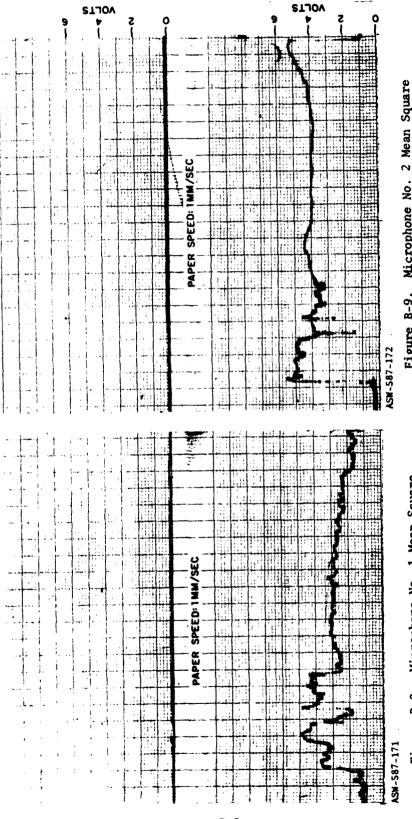
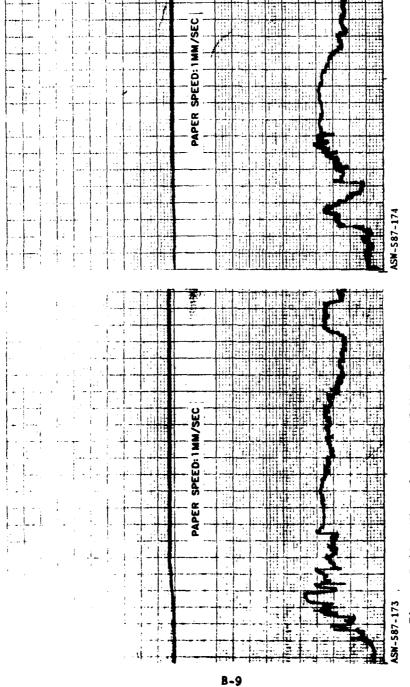


Figure B-8. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

Figure B-9. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

STJOV



NOLTS

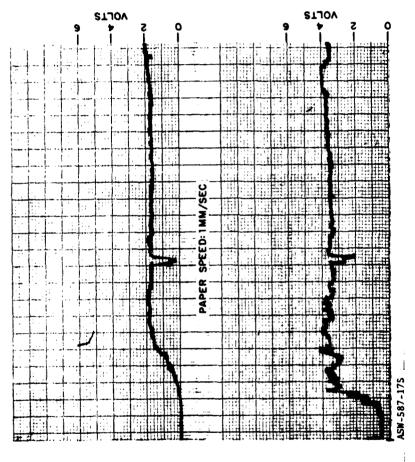
O

Figure B-10. Microphone No. 3 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

Figure B-11. Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

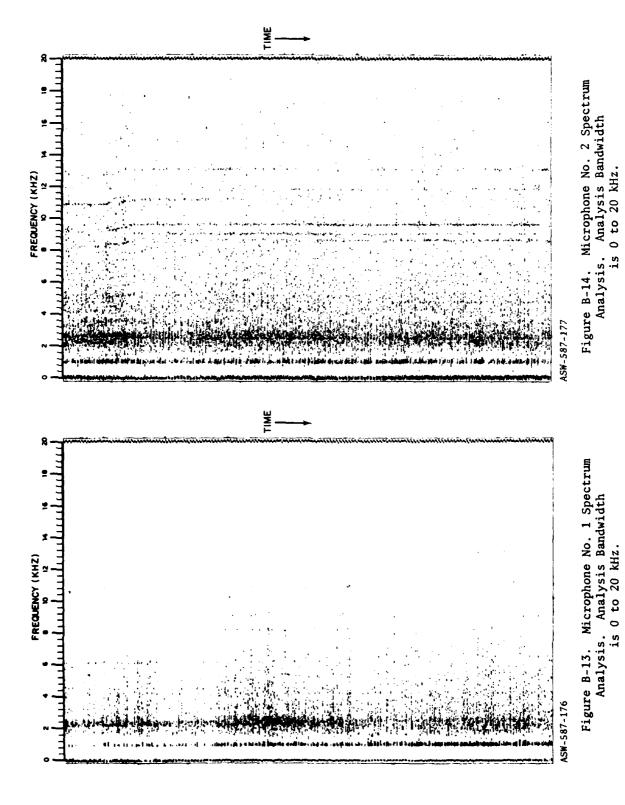
I VOLTS

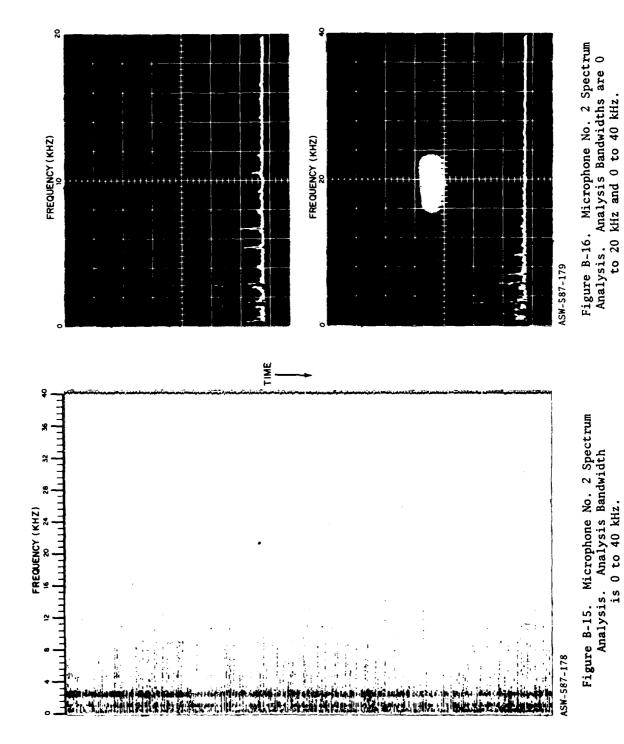
o



1

Figure B-12. Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.





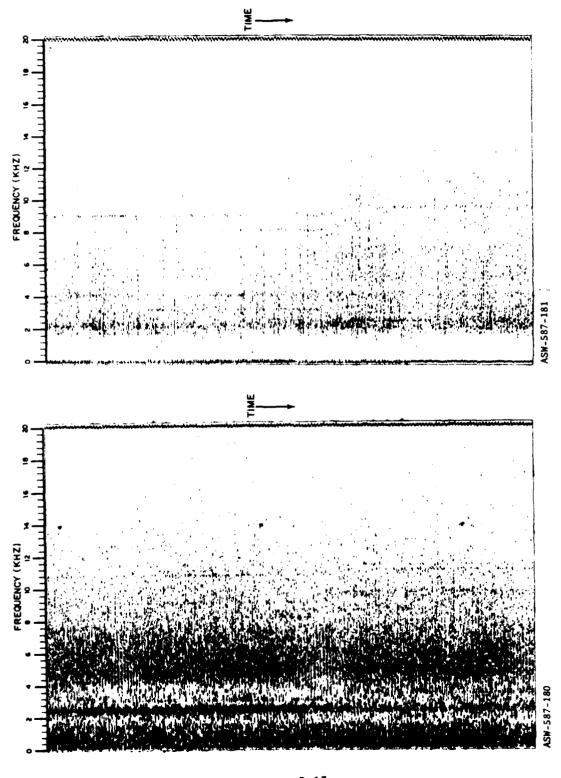


Figure B-18. Microphone No. 4 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

Figure B-17. Microphone No. 3 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

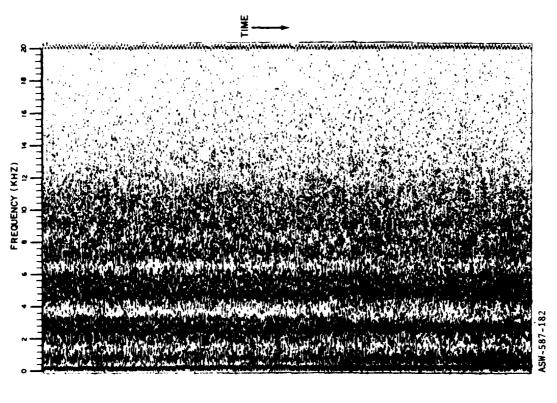
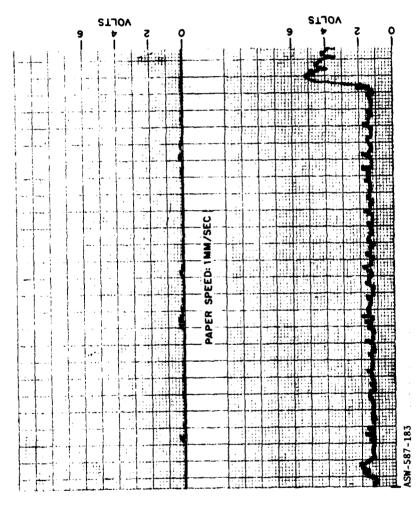


Figure B-19. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. Figure B-20.

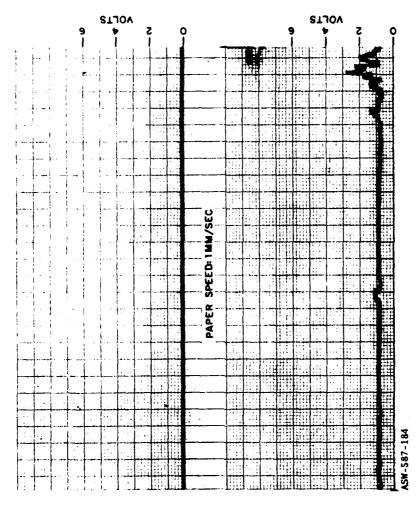
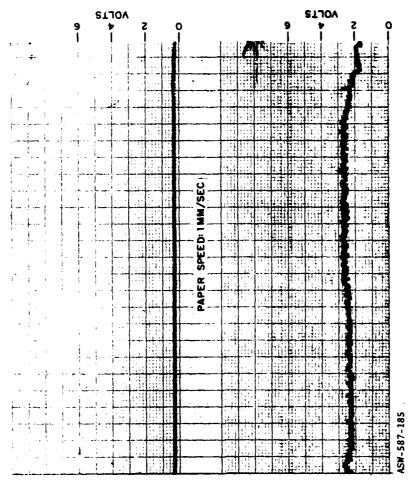
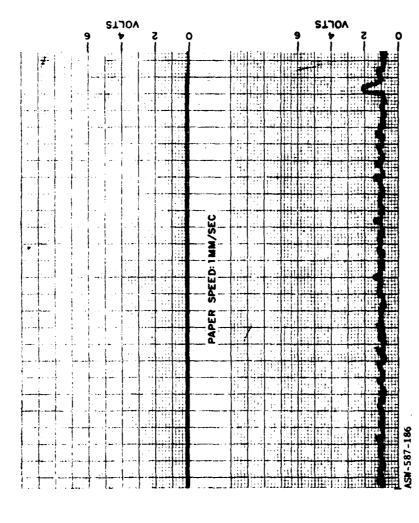


Figure B-21. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

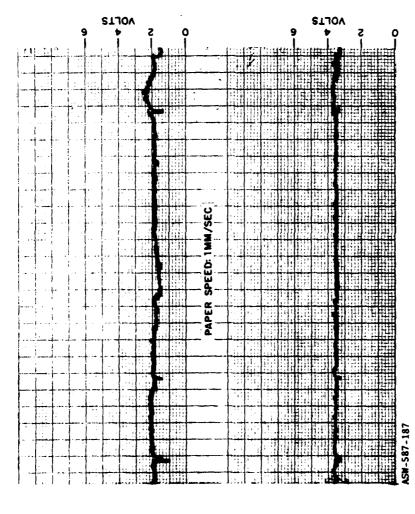


Microphone No. 3 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. Figure B-22.

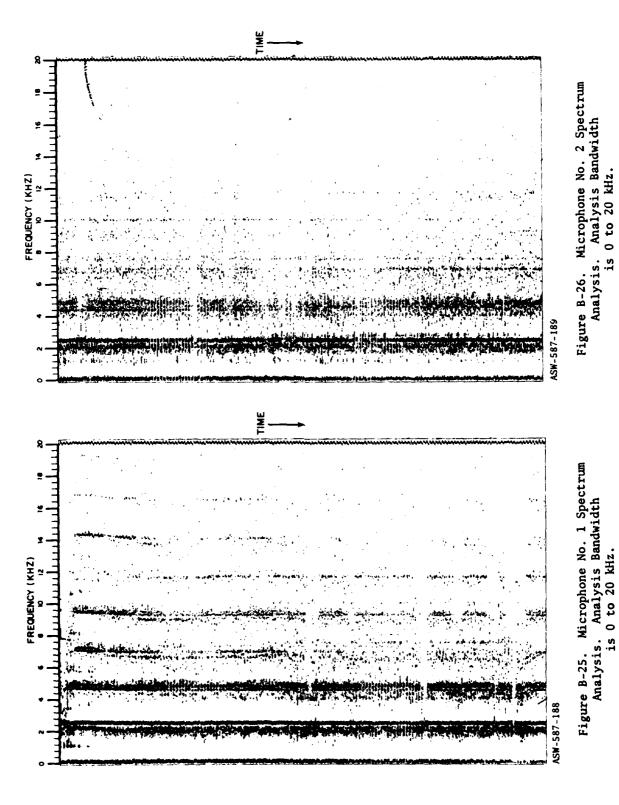


į

Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. Figure B-23.



Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. Figure B-24.



B-20

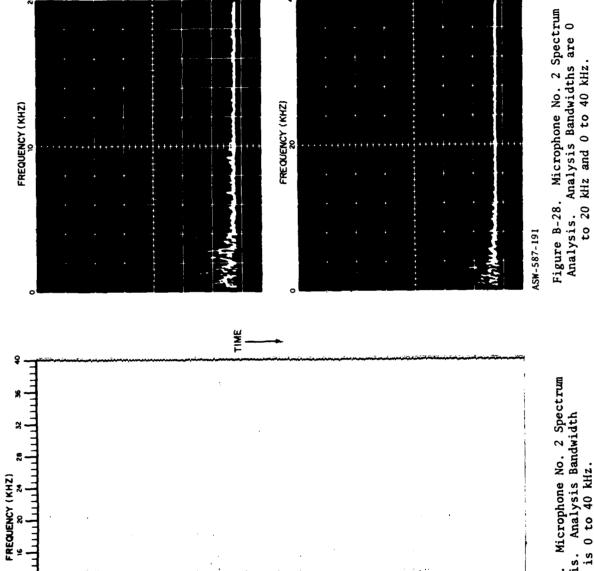


Figure B-27. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 40 kHz.

ASW-587-190

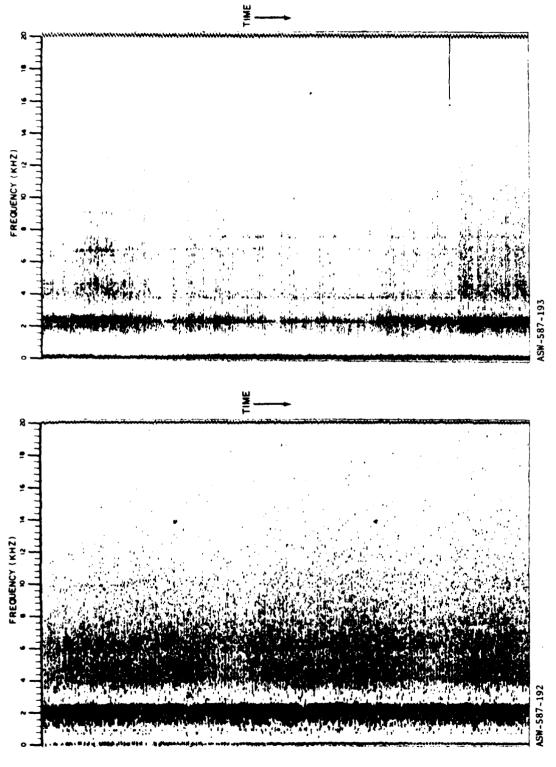


Figure B-29. Microphone No. 3 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

Figure B-30. Microphone No. 4 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

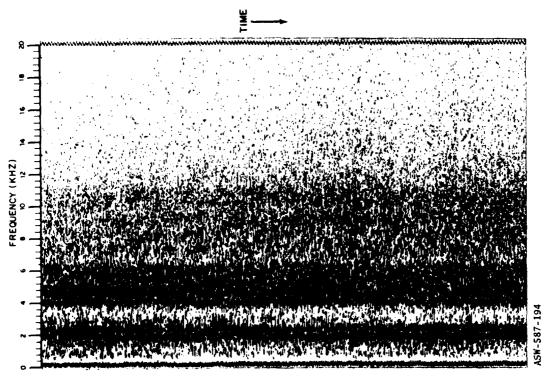
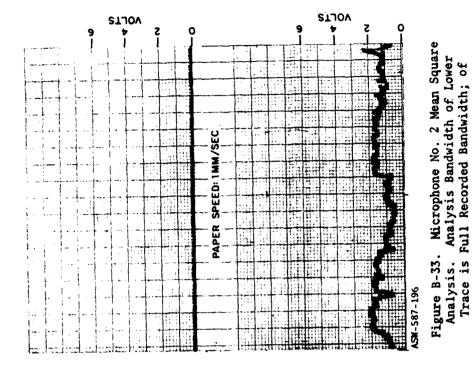


Figure B-31. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

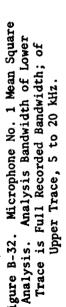


o

PAPER SPEED:1MM/SEC

STION

1



YOLTS

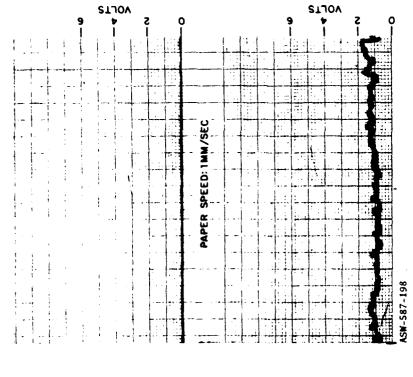
5

o

Upper Trace, 5 to 20 kHz.

Figure B-32. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of

ASW-587-195



STJOY

٥

PAPER SPECULIMM/SEC

9

4

Figure B-35. Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

STJOY

Figure B-34. Microphone No. 3 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

ASW-587-197

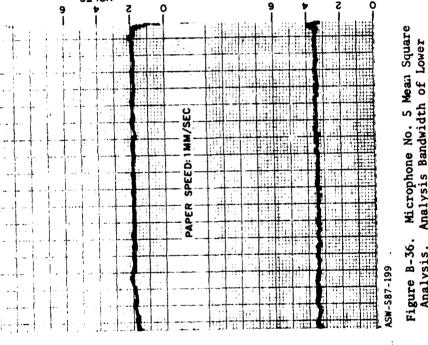


Figure B-36. Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

B.2 J-57 ENGINE (PORT), MODIFIED BURNER CAN HOLE OPEN - 1.5 INCH DIAMETER

A series of three test runs were made on the J-57 engine with the modified burner can hole masked to a 1.5-inch hole. Each test was recorded using five microphones located in the same positions as for the closed hole tests. The three tests were run at the following engine speeds:

- (1) 82% RPM (150 in. Hg gage, diffuser case pressure)
- (2) 90% RPM (240 in. Hg gage, diffuser case pressure)
- (3) Max. RPM (270 in. Hg gage, diffuser case pressure)

The purpose of this test was to determine the sound energy level differential between a closed hole on the modified burner can and a large open hole (1.5 inches in diameter) at like engine speeds.

Analysis of the recordings made during the three runs is given on the following pages:

- (1) 82% run pages B-30 through B-36
- (2) 90% run pages B-37 through B-43
- (3) Max. run pages B-44 through B-50

B.2.1 Analysis

B.2.1.1 Sound Energy Levels

Microphone sound pressure levels stayed almost constant as the engine RPM was increased from 82% to 90% to maximum. There was a 2 to 9 dB increase from the closed-hole test at 82% RPM to the open-hole test. The greatest change in pressure level occurred in microphone 4, which was the second closest to the open hole, and the least pressure level occurred in microphone 2, which was the closest to the hole. A greater change, 3 to 17 dB, was noted between open-hole and closed-hole readings at 90% and maximum RPM. Microphone 4 showed the greatest change and microphone 5, which was farthest from the hole, showed the least change. Microphones 1, 2, and 4 showed the greatest increase, due to their proximity to the open hole, while microphones 3 and 5 showed the least and were farthest from the hole.

B.2.1.2 Spectrum Analysis

The grams were consistent throughout the three test runs from microphone to microphone. The only noticeable change was in gram density as RPM increased. Some discrete frequency lines, all of which were below 10 kHz, were visible. As in previous runs, these lines were caused by engine machinery. Microphone 2, the instrumentation microphone, showed broadband random noise to 40 kHz, the bulk of which was

below 20 kHz. The microphone 5 gram contained the most random noise. The discrete frequencies which appeared in the covered hole test at 82% RPM were apparently masked out by the broadband random noise.

B.2.1.3 Mean Square Analysis

The mean square analysis recordings showed most of the open-hole energy to be above 5 kHz when compared with the closed hole tests. Burner can "flame on" can clearly be seen in the 90% and maximum RPM runs. It is also seen that the "flame" in the burner can creates frequencies primarily above 5 kHz.

B.2.2 Environmental Conditions

The three tests discussed in paragraph B.2 were performed at an ambient temperature of 77° F and 25% relative humidity. Microphone temperatures were as follows:

	MICROPHONE					
	1	2	3	4	5	
TEMPERATURE (°F)	120	160	70 (a)	140	60 (a)	

B.2.3 Sound Energy Levels

The following tables list the sound energy levels of the five microphones at three engine test speeds:

Table B-4. Microphone Sound Energy Levels at 82% Engine RPM

			MICROPHONE		······································
SOUND LEVEL	1	2	3	4	5
RMS (mV)	170	62	61	210	59
RMS (µBAR)	1380	4800	490	1700	470
dB (a)	137	148	128	138	127

 $a_{Reference} = 2 \times 10^{-4} \mu BAR$

Table B-5. Microphone Sound Energy Levels at 90% Engine RPM

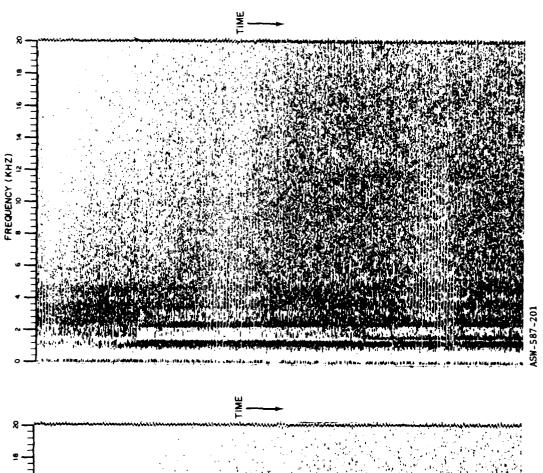
			MI CROPHONE		
SOUND LEVEL	1	2	3	4	5
RMS (mV)	200	65	70	230	60
RMS (µBAR)	1600	5100	560	1850	480
dB (a)	138	148	129	139	128

 $a_{Reference} = 2 \times 10^{-4} \mu BAR$

Table B-6. Microphone Sound Energy Levels at Maximum Engine RPM

			MICROPHONE		
SOUND LEVEL	1	2	3	4	5
RMS (mV)	200	65	72	230	60
RMS (μBAR)	1600	5100	580	1850	480
dB (a)	138	148	129	139	128

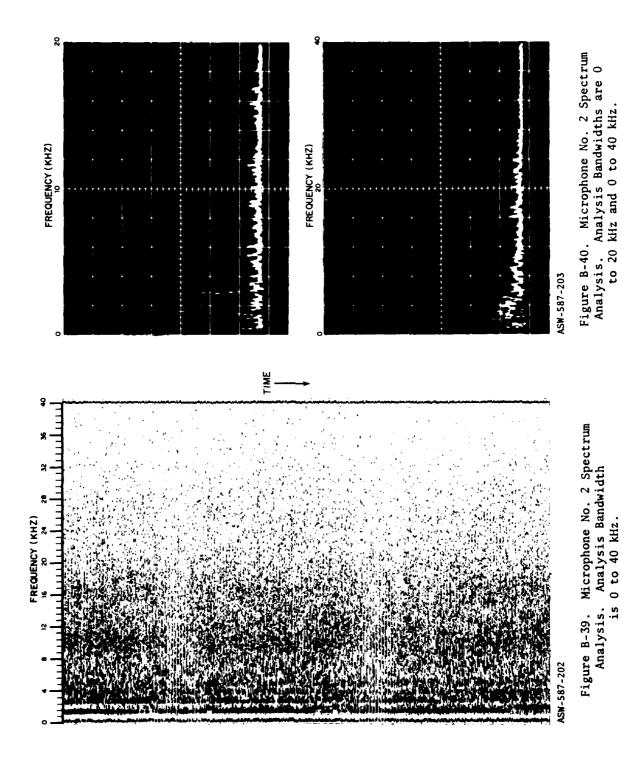
^aReference = $2 \times 10^{-4} \mu BAR$



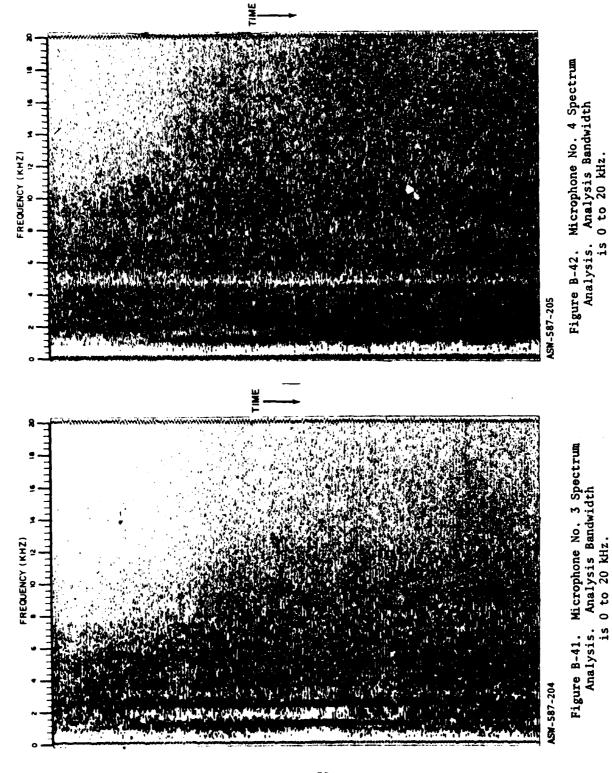
FREQUENCY (KHZ)

Figure B-37. Microphone No. 1 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

Figure B-38. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



B-31



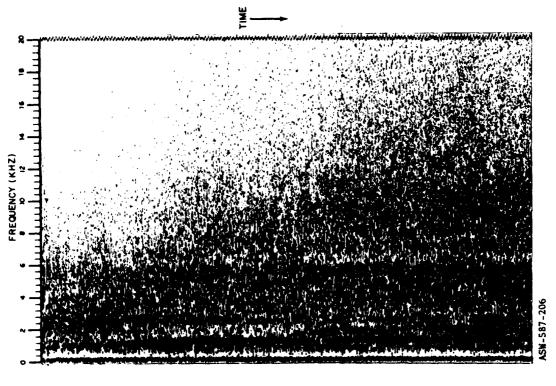


Figure B-43, Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

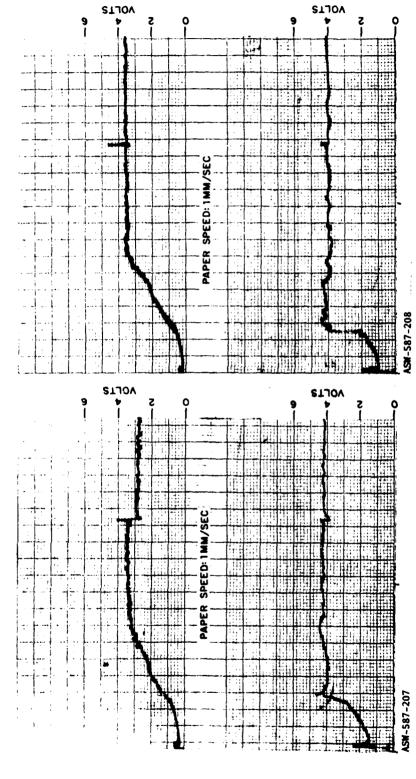


Figure B-45. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

Figure B-44. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of

Upper Trace, 5 to 20 kHz.

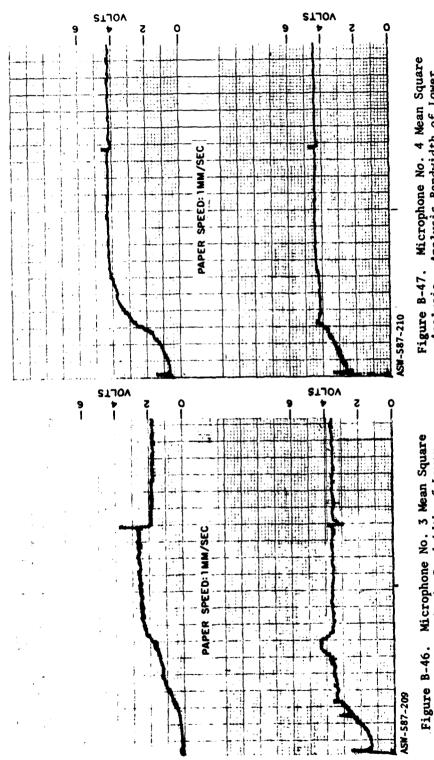
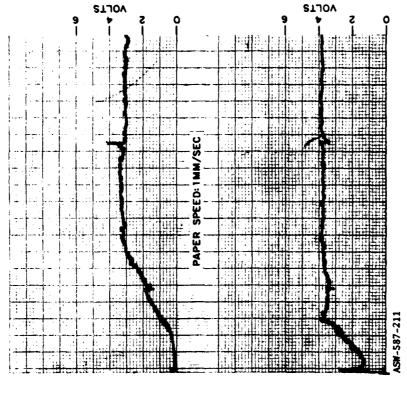


Figure B-47. Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

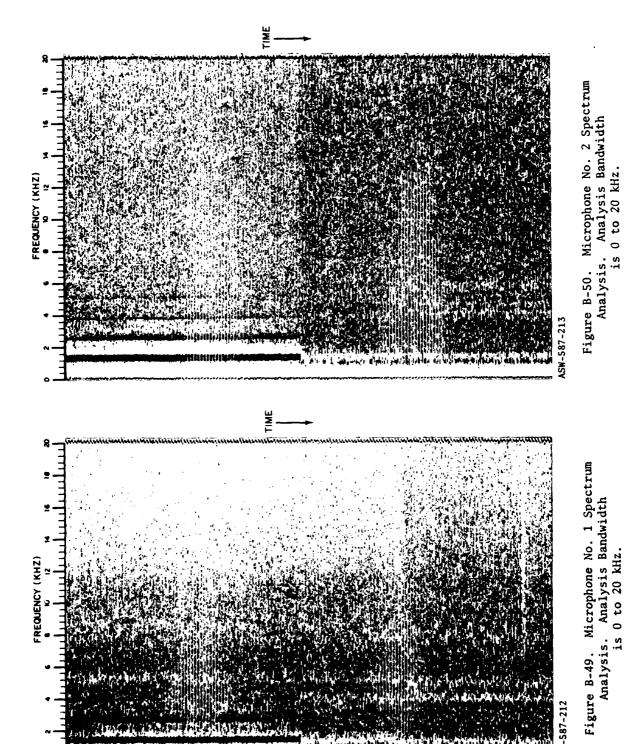
Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

,



-Figure B-48. Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

TO STATE OF THE PARTY OF THE PA



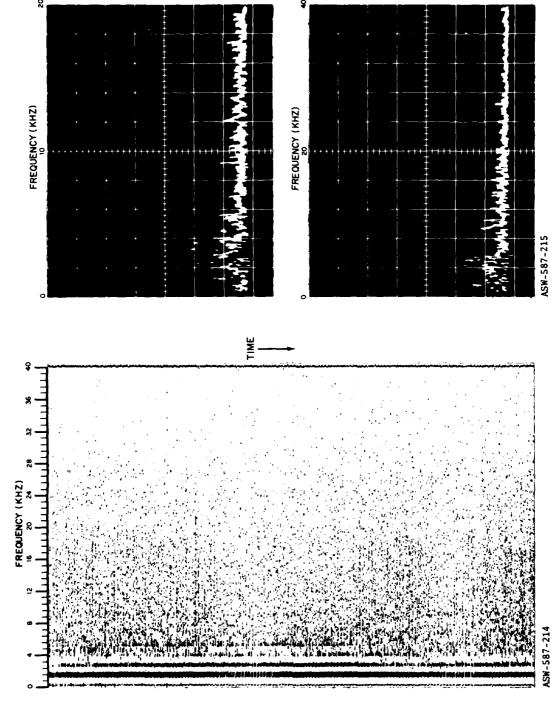


Figure B-52. Microphone No. 2 Spectrum Analysis. Analysis Bandwidths are 0 to 20 kHz and 0 to 40 kHz.

Figure B-51. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 40 kHz.

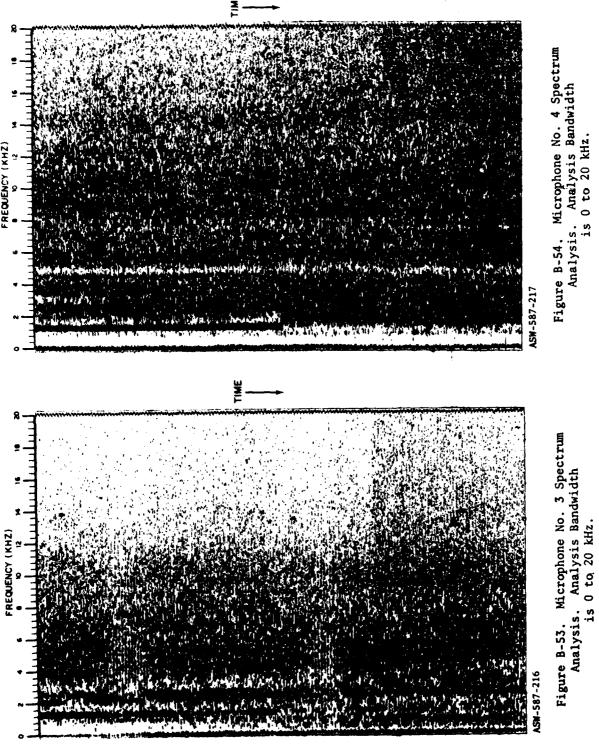


Figure B-54. Microphone No. 4 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

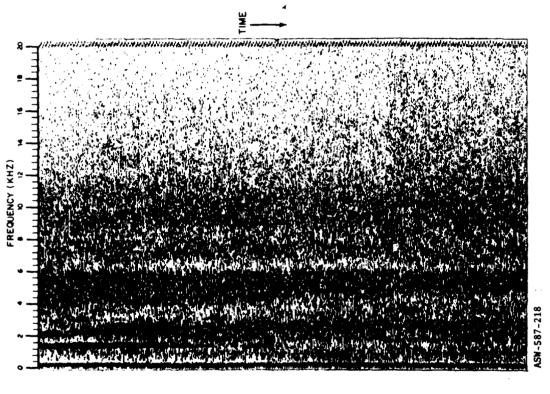
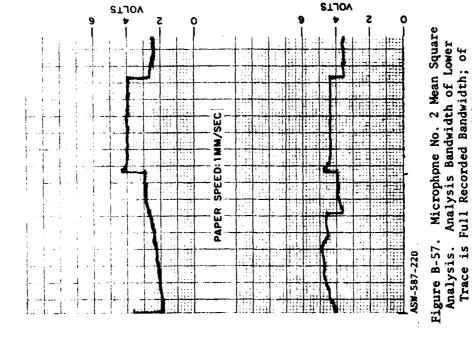


Figure B-55. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



PAPER SPEED: 1MM/SEC

STION

9

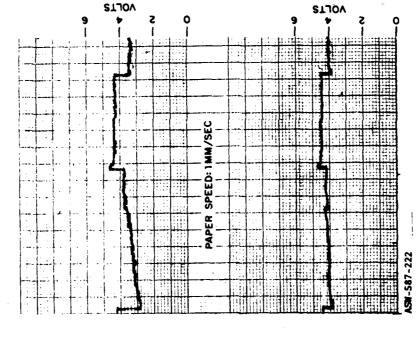
1

Upper Trace, 5 to 20 kHz.

Figure B-56. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

ASW-587-219

VOLTS



PAPER SPEED: 1MM/SEC

YOLTS

9

Figure B-59. Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

ASW-587-221
Figure B-58. Microphone No. 3 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

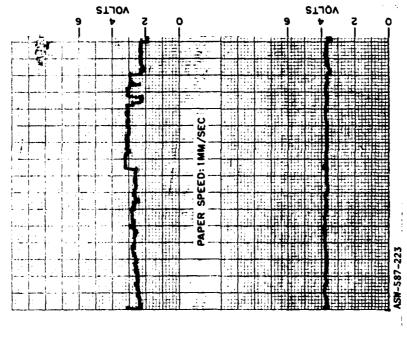


Figure B-60. Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

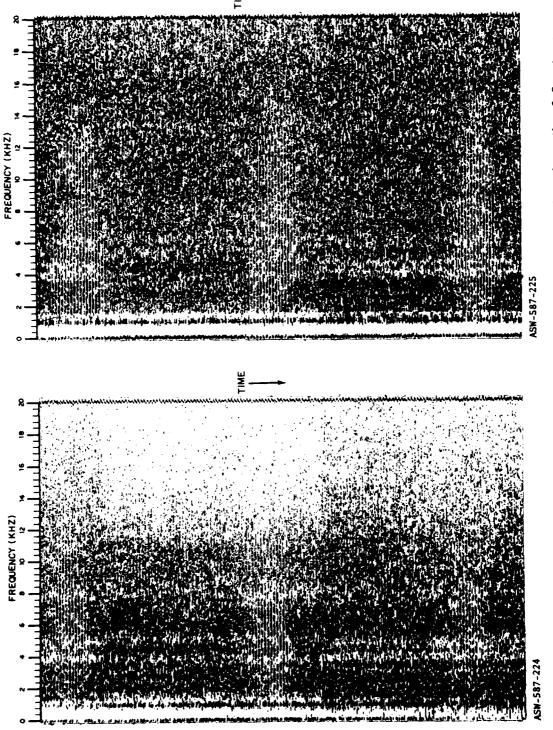
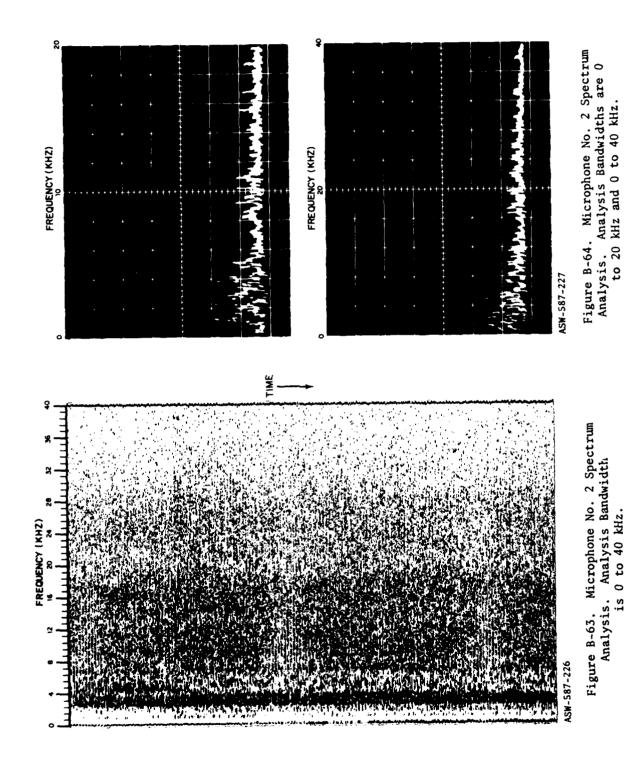
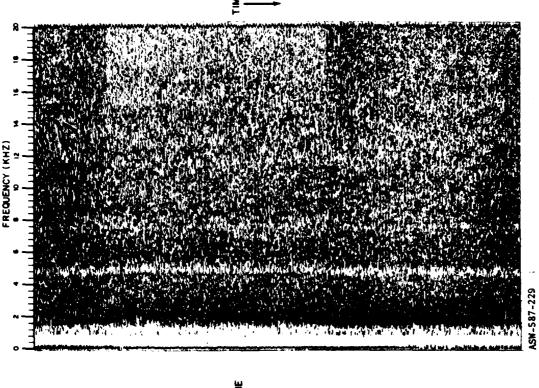


Figure B-62. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

Figure B-61. Microphone No. 1 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

B-44







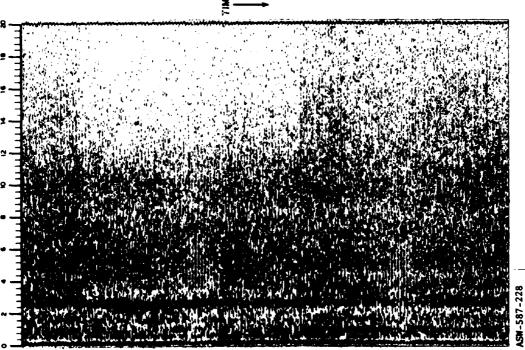


Figure B-65. Microphone No. 3 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

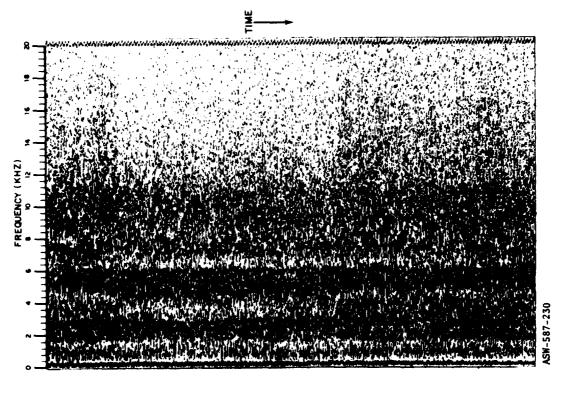
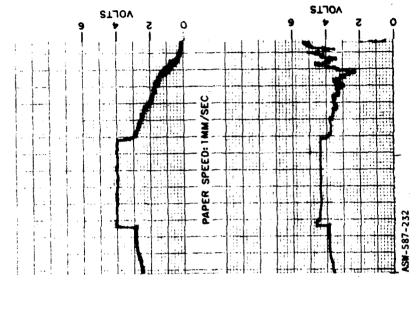


Figure B-67. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



PAPER SPEED: IMM/SEC

Figure B-69. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

Figure B-68. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

- 一大大大学の大大大学の大大大学の

ASW-587-231

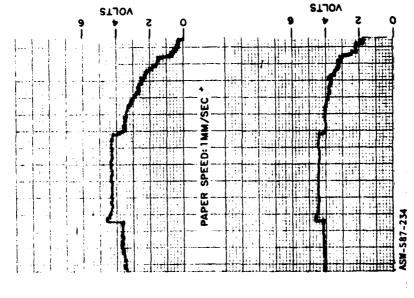
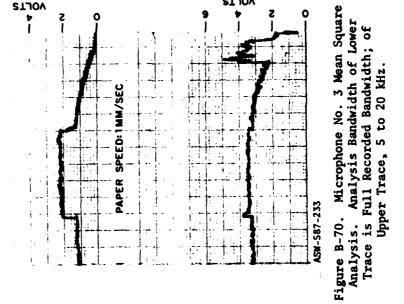


Figure B-71. Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.



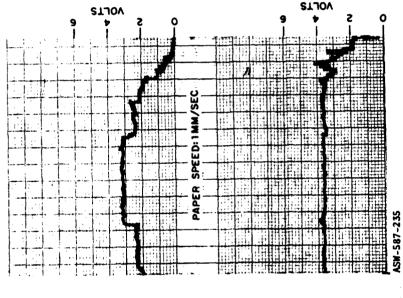


Figure B-72. Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

B.3 J-57 ENGINE (PORT), MODIFIED BURNER CAN HOLE OPEN - 1.0-INCH DIAMETER

A series of three test runs were made on the J-57 engine with the modified burner can hole masked to a 1.0-inch hole. Each test was recorded using five microphones located in the same positions as for the closed-hole tests. The three tests were run at the following engine speeds:

- (1) 82% RPM (150 in. Hg gage, diffuser case pressure)
- (2) 90% RPM (240 in. Hg gage, diffuser case pressure)
- (3) Max. RPM (270 in. Hg gage, diffuser case pressure)

The purpose of this test was to determine the sound energy level differential between a closed hole on the modified burner can and a medium open hole (1.0 inch in diameter) at like engine speeds.

Analysis of the recordings made during the three runs is given on the following pages:

- (1) 82% run pages B-53 through B-61
- (2) 90% run pages B-62 through B-68
- (3) Max. run pages B-69 through B-75

B.3.1 Analysis

B.3.1.1 Sound Energy Levels

The 1.0 inch open-hole readings were similar to the 1.5-inch open-hole readings except that they were slightly lower. This was probably due to hole size reduction. Microphones 3 and 5, which were farthest from the open hole, showed the least change (1 dB drop) while microphones 1 and 4, which were close to the hole, showed 3 to 5 dB drops. Microphone 2, a different type for this run than was used for the closed hole and 1.5 inch open-hole test, is not directly comparable.

As in the closed-hole test, the 82% RPM was very noisy. A greater differential between closed-hole and open-hole tests appear in the 90% and maximum RPM runs.

B.3.1.2 Spectrum Analysis

The grams for this test were almost identical to the 1.5-inch open-hole test. There were no distinct characteristic differences from those noted in the 1.5-inch open-hole test.

B.3.1.3 Mean Square Analysis

The mean square analysis recordings showed a greater portion of the spectral content to be above 5 kHz than for the 1.5-inch open-hole and closed-hole tests. Burner can "flame on" was not as distinct as for the 1.5-inch open-hole test.

B.3.2 Environmental Conditions

The three tests discussed in paragraph B.3 were performed at an ambient temperature of 68° F and 78% relative humidity.

B.3.3 Sound Energy Levels

The following tables list the sound energy levels of the five microphones at three engine test speeds:

Table B-7. Microphone Sound Energy Levels at 82% Engine RPM

SOUND LEVEL	MICROPHONE					
	11	2	3	4	5	
RMS (mV)	88	115	62	145	47	
RMS (µBAR)	630	930	500	1150	380	
dB (a)	131	133	128	135	125	

 $^{^{}a}$ Reference = 2 x 10^{-4} μ BAR

Table B-8. Microphone Sound Energy Levels at 90% Engine RPM

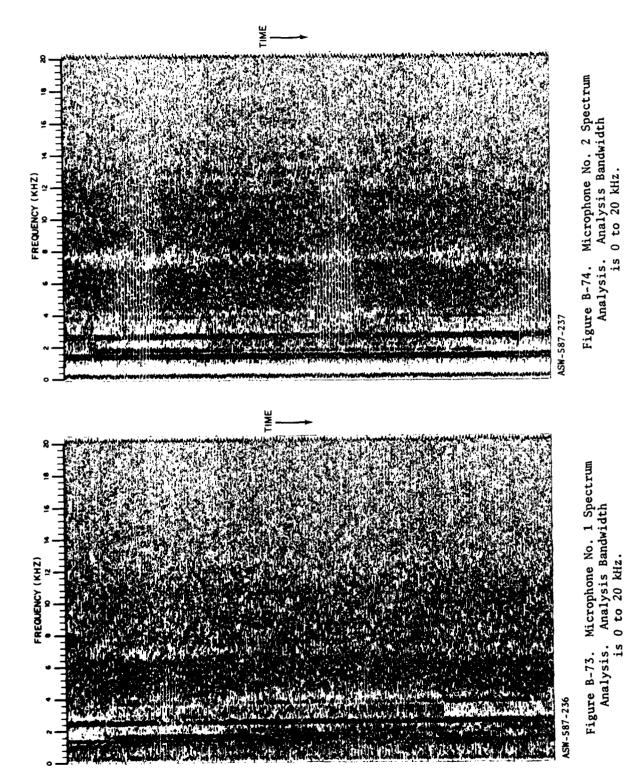
SOUND LEVEL	MICROPHONE					
	1	2	3	4	5	
RMS (mV)	95	125	65	125	54	
RMS (µBAR)	760	1000	520	1000	430	
dB (a)	132	134	128	134	127	

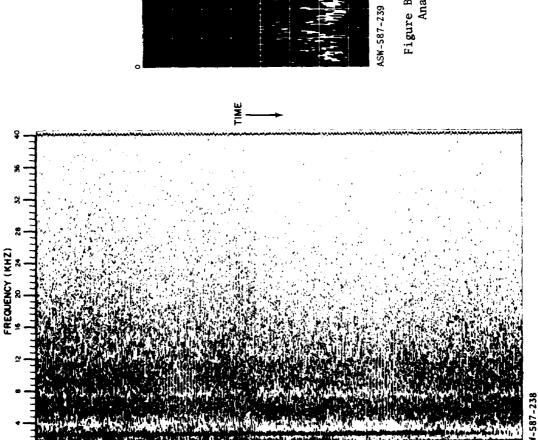
aReference = 2 x 10^{-4} μ BAR

Table B-9. Microphone Sound Energy Levels at Maximum Engine RPM

SOUND LEVEL	MICROPHONE					
	1	2	3	4	5	
RMS (mV)	100	130	78	130	60	
RMS (µBAR)	800	1040	630	1040	480	
dB (a)	132	134	130	134	128	

^aReference = $2 \times 10^{-4} \mu BAR$





FREQUENCY (KHZ)

Figure B-76. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

B-54

54

A PARTY OF

Figure B-75. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 40 kHz.

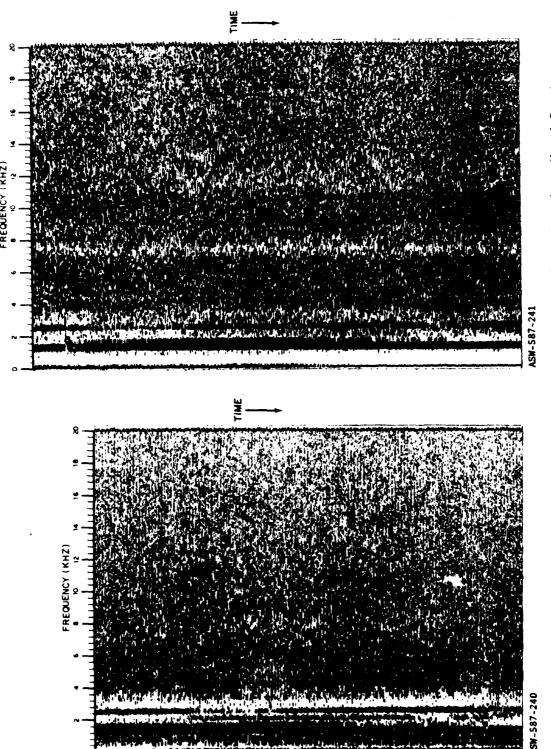


Figure B-78, Microphone No. 4 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz. Figure B-77. Microphone No. 3 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

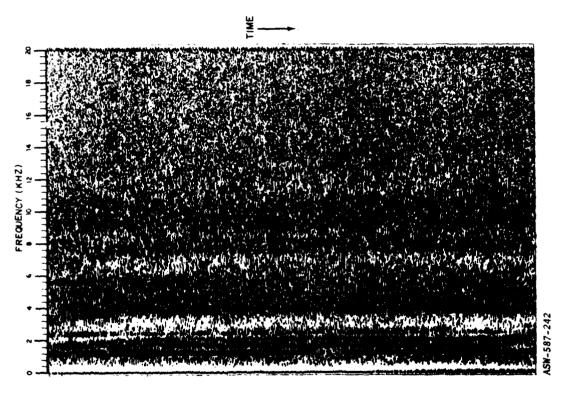


Figure B-79. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

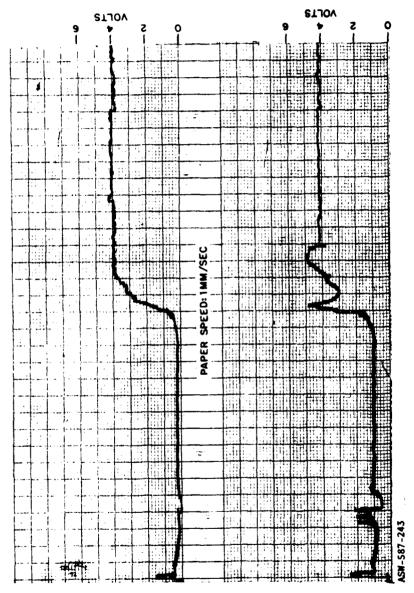


Figure B-80. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

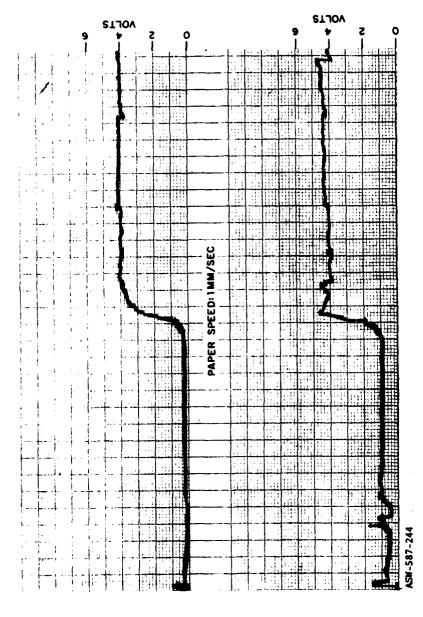


Figure B-81. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

The second state of the second

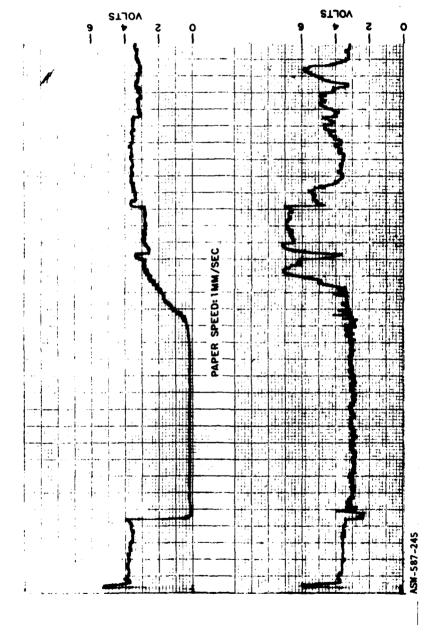


Figure B-82. Microphone No. 3 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

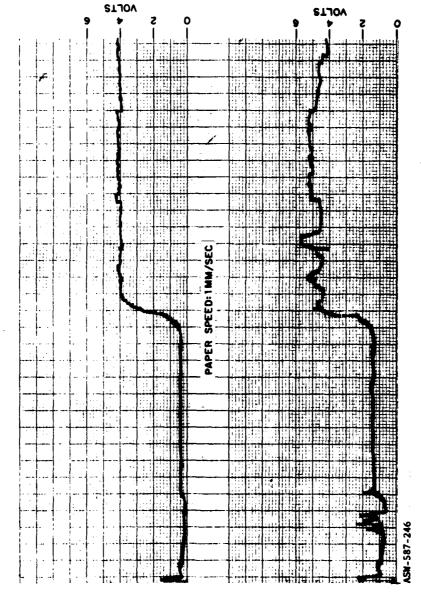


Figure B-83. Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

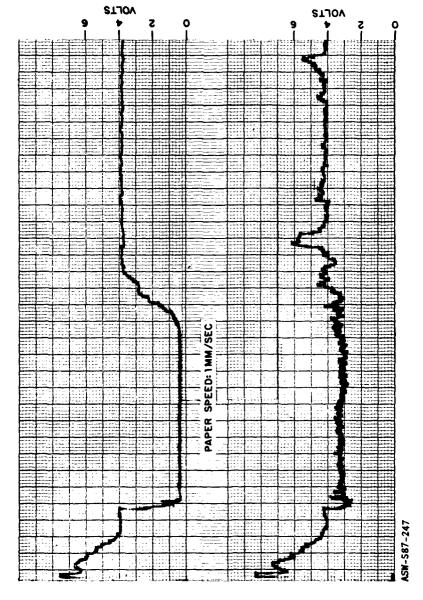
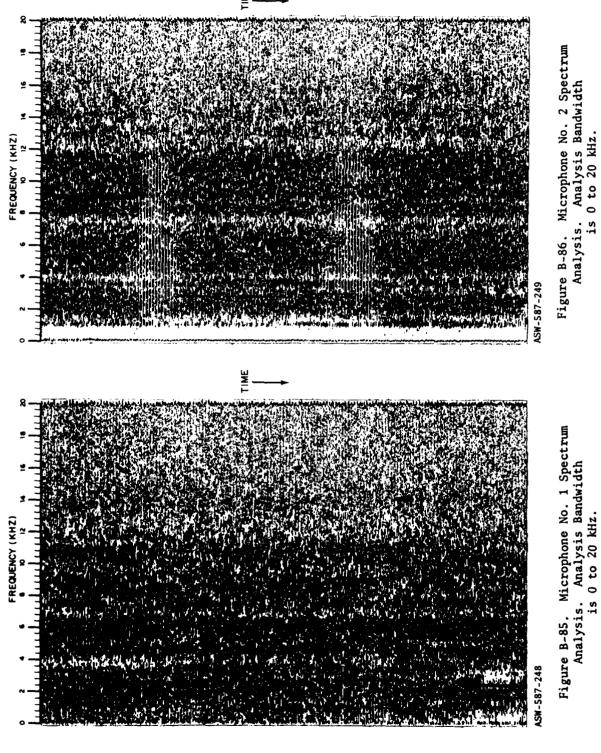


Figure B-84. Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.



.:: *

Figure B-86. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

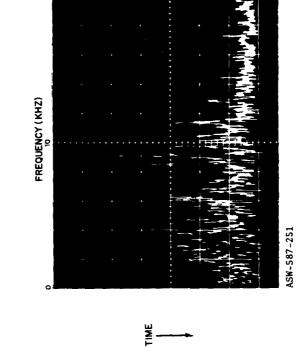


Figure B-88. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

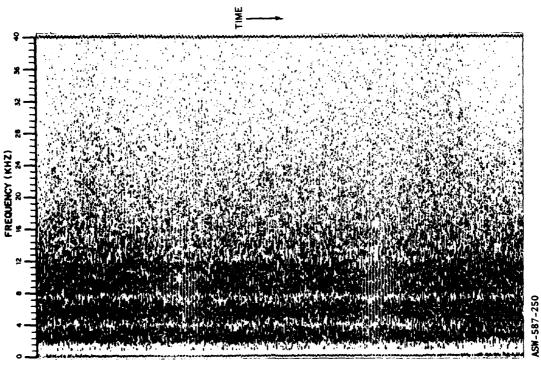


Figure B-87. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 40 kHz.

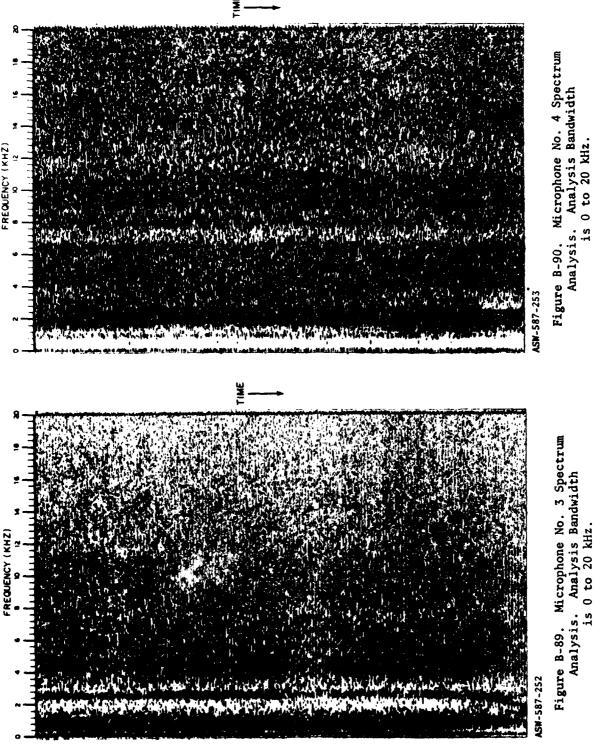


Figure B-90. Microphone No. 4 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

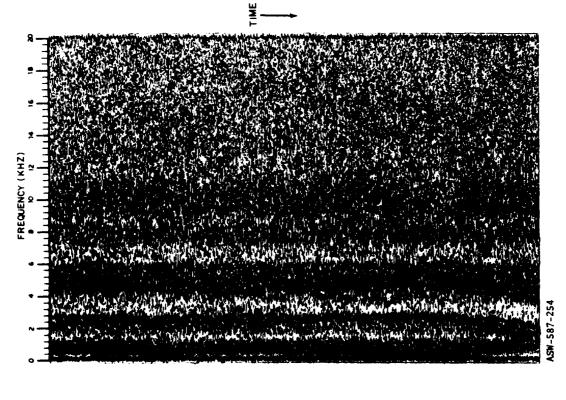
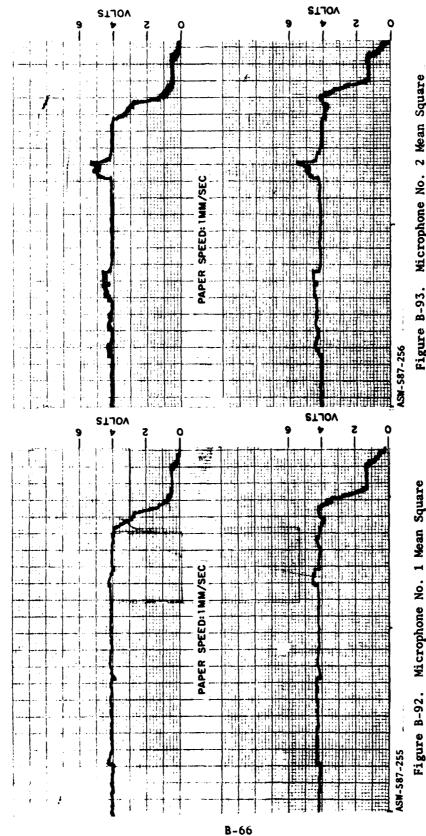


Figure B-91. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. Figure B-93.

Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

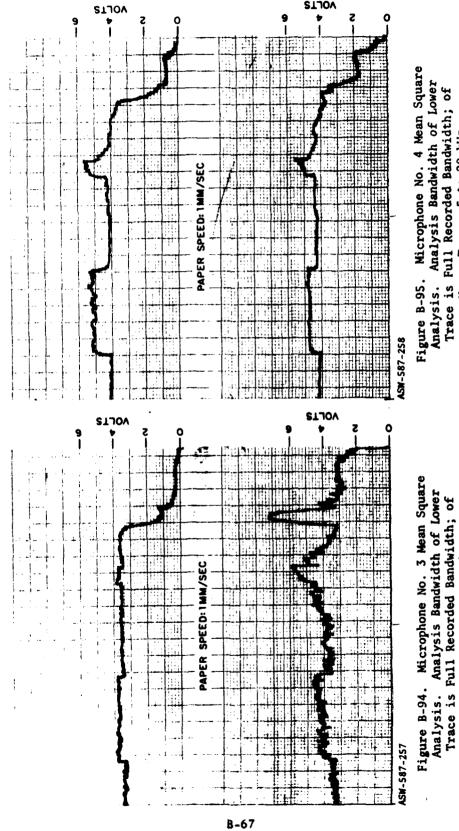


Figure B-95. Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

Upper Trace, 5 to 20 kHz.

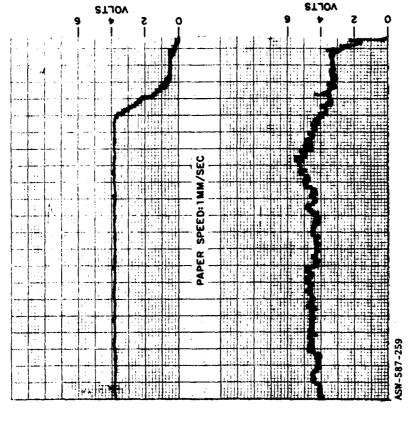
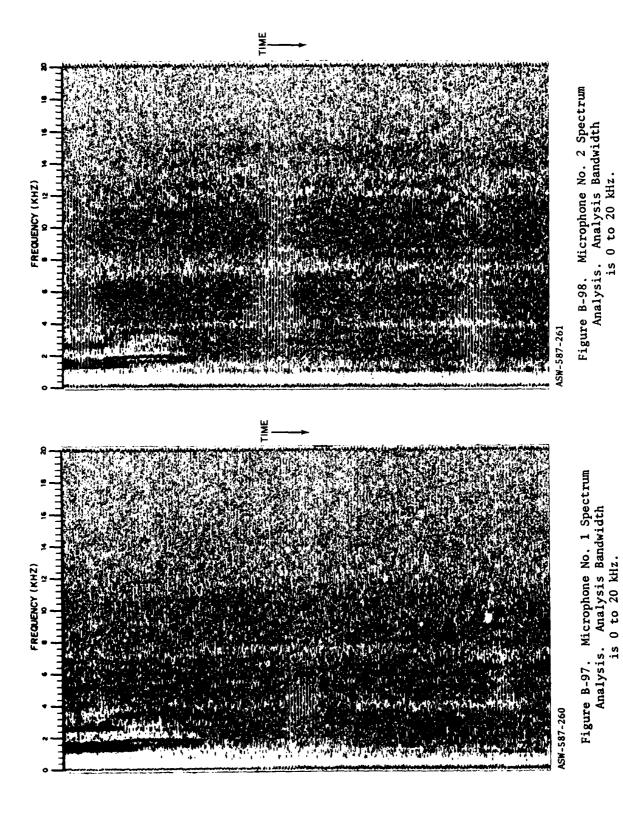


Figure B-96. Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.



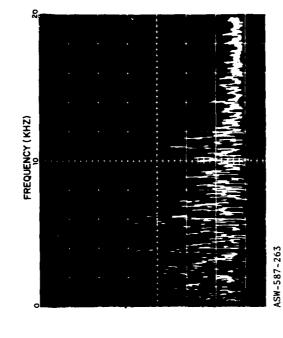


Figure B-100. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

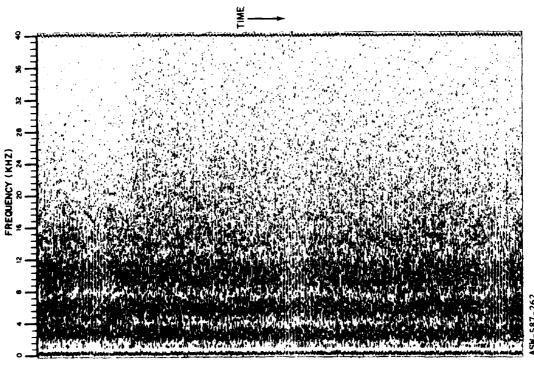
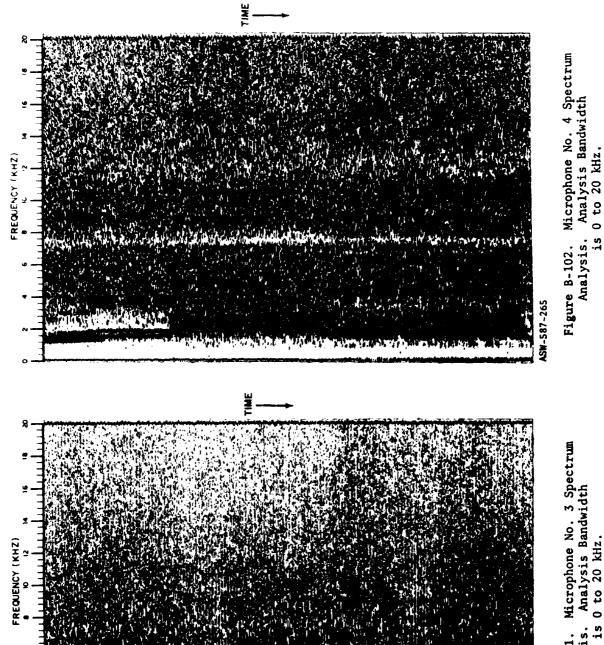


Figure B-99. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 40 kHz.



 Microphone No. 3 Spectrum
 Analysis Bandwidth
 to 20 kHz. Figure B-101. | Analysis.

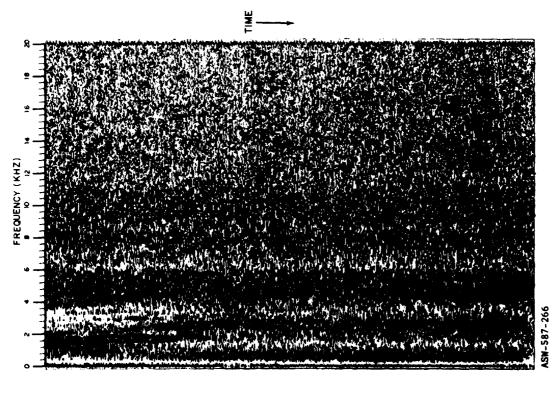


Figure B-103. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

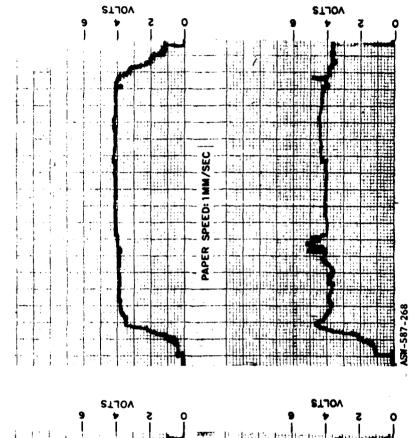
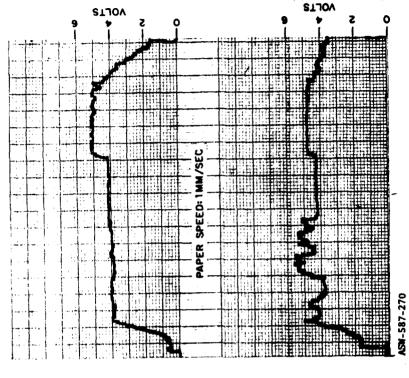


Figure B-105. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

Figure B-104. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

ASN-587-267

PAPER SPEED: IMM/SEC



ò

PAPER SPEED: IMM/SEC

:

STJOY



VOLTS

Figure B-106. Microphone No. 3 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

ASM-587-269

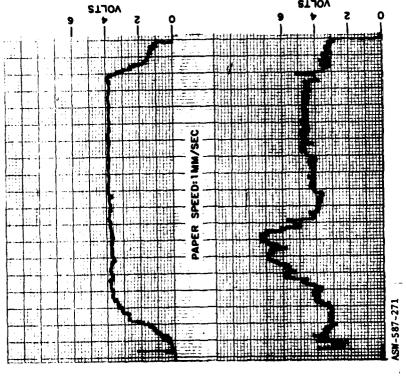


Figure B-108. Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

B.4 J-57 ENGINE (PORT) MODIFIED BURNER CAN HOLE OPEN - 0.75 INCH

A series of three test runs were made on the J-57 engine with the modified can hole masked to a 0.75-inch hole. Each test was recorded using five microphones located in the same positions as for the closed hole tests. The three tests were run at the following engine speeds:

- (1) 82% RPM (150 in. Hg gage, diffuser case pressure)
- (2) 90% RPM (240 in. Hg gage, diffuser case pressure)
- (3) Max. RPM (270 in. Hg gage, diffuser case pressure)

The purpose of this test was to determine the sound energy level differential between a closed hole on the modified burner can and a small open hole (0.75 inch in diameter) at like engine speeds.

Analysis of the recordings made during the three runs is given on the following pages:

- (1) 82% run pages B-78 through B-86
- (2) 90% run pages B-87 through B-93
- (3) Max. run pages B-94 through B-100

B.4.1 Analysis

B.4.1.1 Sound Energy Levels

Further reduction in hole size yielded further reduction in meter readings. The least change appeared on microphones 3 and 5, as was the case in the 1-inch open-hole test. These microphones were farthest from the open hole. There was only a 1 to 2 dB differential for the 82% RPM run between the closed-hole and 0.75-inch open hole-test. A similarity between the closed-hole and 0.75-inch open-hole tests appeared for all microphones. The higher energy levels apparent in the closed-hole test, due to machinery frequencies at 82% RPM, also appeared in the 82% RPM, 0.75-inch open-hole test. The sound levels dropped at 90% RPM and stayed the same or increased slightly at maximum RPM closely following the closed hole results. The microphones close to the open hole showed a 3 to 8 dB increase over closed-hole tests at maximum RPM.

B.4.1.2 Spectrum Analysis

The grams from this test, at 82% RPM, are similar to the closed-hole tests in that there are many discrete machinery frequencies visable with what could be called an overlay of broadband noise. It is again apparent that the random noise created by the open-hole masks the discrete machinery frequencies.

B.4.1.3 Mean Square Analysis

The microphones farthest from the open hole contained a greater quantity of the spectrum below 5 kHz than did those located close to the hole. Recordings from microphones 3 and 5 in the 0.75 inch open-hole test are especially good examples of this fact. Microphones 1, 2, and 4 showed much less spectrum below 5 kHz.

B.4.2 Environmental Conditions

The three tests discussed in paragraph B.4 were performed at an ambient temperature of 68°F and 78% relative humidity.

B.4.3 Sound Energy Levels

The following tables list the sound energy levels of the five microphones at three engine test speeds:

Table B-10. Microphone Sound Energy Levels at 82% Engine RPM

COLUMN TENES	MI CROPHONE									
SOUND LEVEL	11	2	3	4	5					
RMS (mV)	72	92	60	110	42					
RMS (µBAR)	580	740	480	880	340					
dB (a)	129	131	128	133	124					

^aReference = $2 \times 10^{-4} \mu BAR$

Table B-11. Microphone Sound Energy Levels at 90% Engine RPM

GOLDID I DIET	MI CROPHONE								
SOUND LEVEL	1 1	2	3	4	5				
RMS (mV)	52	68	54	70	50				
RMS (µBAR)	420	540	430	560	400				
dB (a)	126	129	127	129	126				

^aReference = $2 \times 10^{-4} \mu BAR$

Table B-12. Microphone Sound Energy Levels at Maximum Engine RPM

gothin raint			MICROPHONE		
SOUND LEVEL	1	2	3	4	5
RMS (mV)	66	80	70	88	52
RMS (µBAR)	520	640	560	700	420
dB (a)	128	130	129	130	126

 a Reference = 2 x 10^{-4} μ BAR

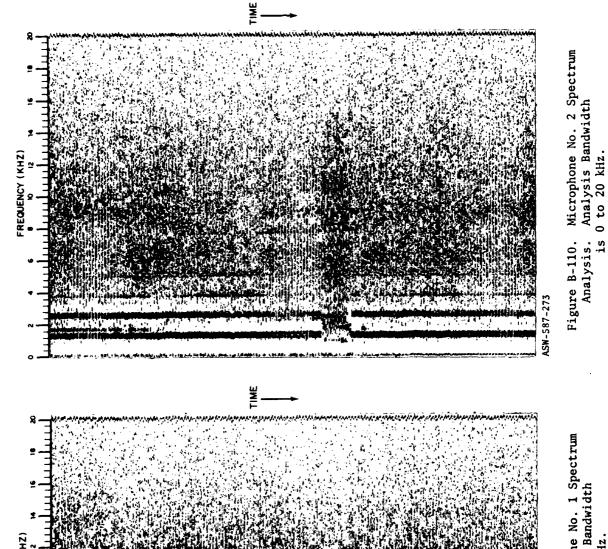
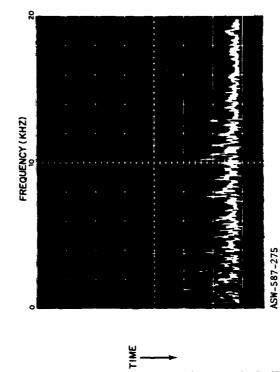
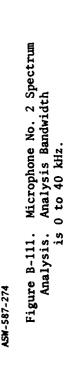


Figure B-109. Microphone No. 1 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



FREQUENCY (KHZ)

Figure B-112. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



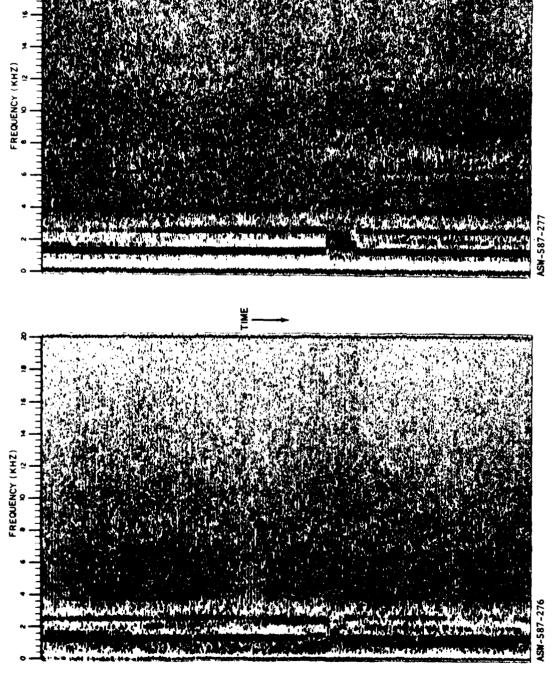


Figure B-114. Microphone No. 4 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

Microphone No. 3 Spectrum
 Analysis Bandwidth
 to 20 kHz.

Figure B-113. Analysis.

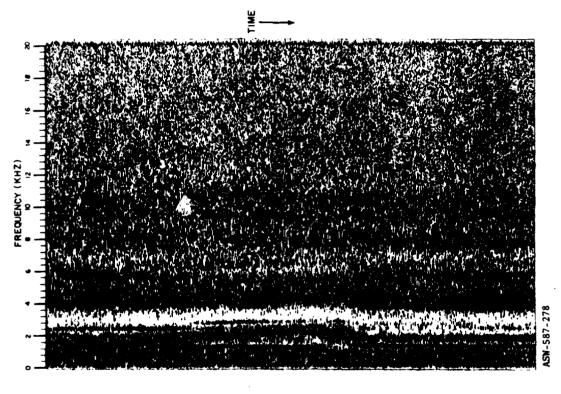


Figure B-115. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

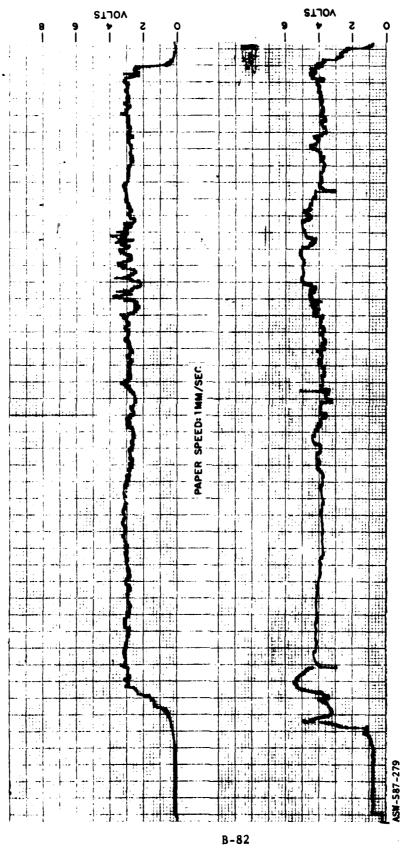
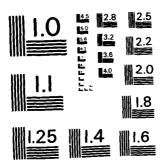


Figure B-116. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

. 13 2 357 . ASSIFIE	16	515 KAI	. UAIAI	U) MARKET	MATUK (20 FORT	10N VOI WAYNE 72-96-2	IND FO 2 DOT-F	RT WAY	NE 3/	4	
				i i	7 = 1 1	<u> </u>				1		2.3
			ų.	1			[.]	1	بندن. انت			
		i i	ŧ				ا پي	1	===== <u>.</u>	£ .		
							. ,		ż			
				1	4.	·						
(i i	(i	ı				į
		4	16 1 3									



MICROCOPY RESOLUTION TEST CHART NATIONAL BUREAU OF STANDARDS - 1963 - A

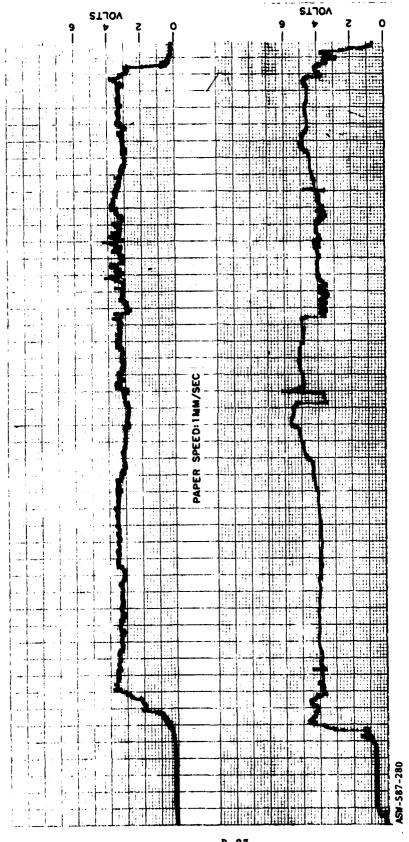


Figure B-117. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

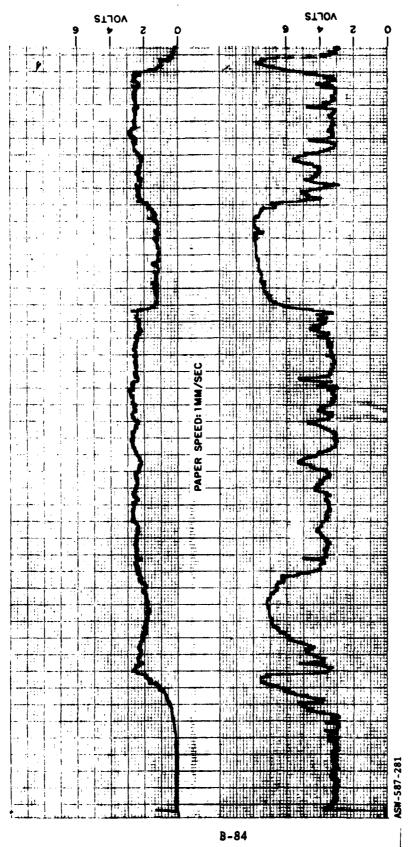


Figure B-118. Microphone No. 3 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

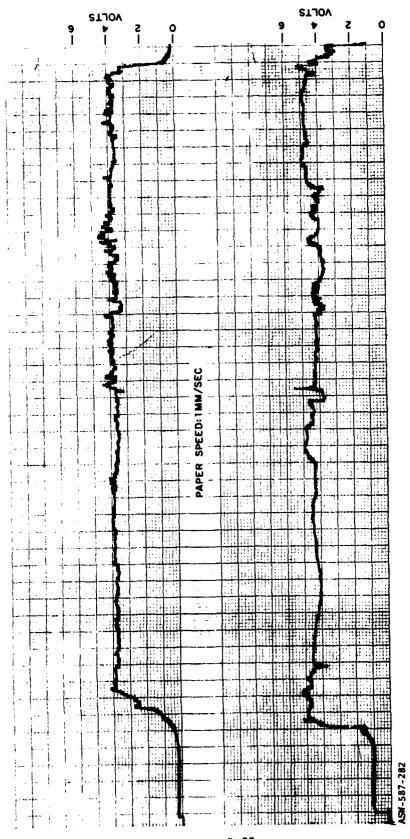


Figure B-119. Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

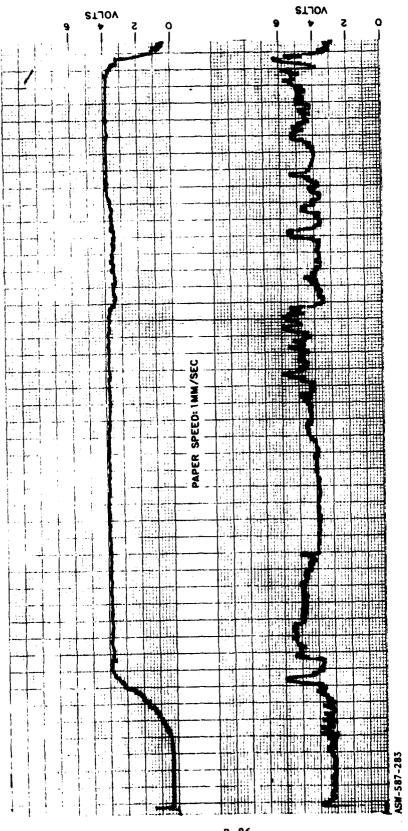
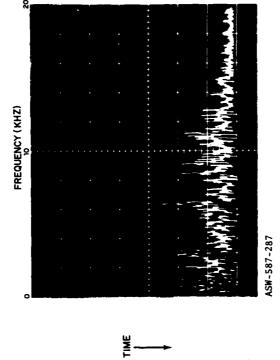


Figure B-120. Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.



Figure B-122. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

Figure B-121. Microphone No. 1 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



FREQUENCY (KHZ)

Figure B-124. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

Figure B-123. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 40 kHz.

ASW-587-286

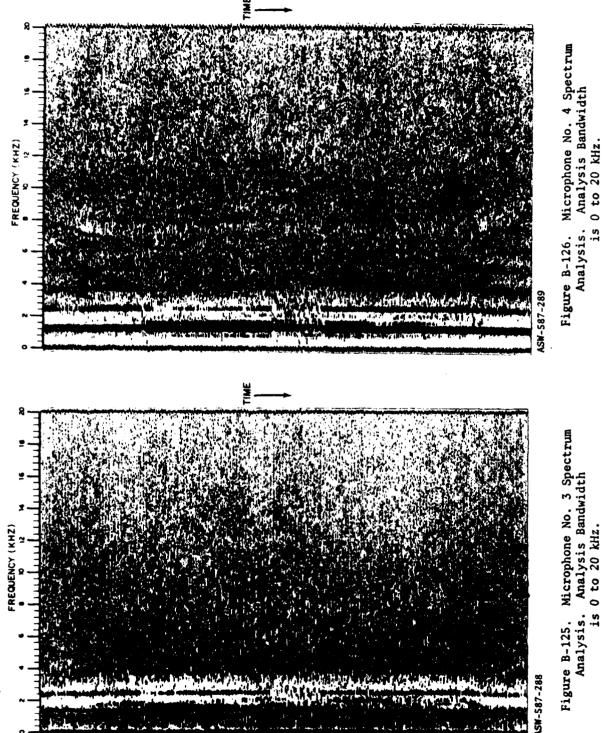


Figure B-126. Microphone No. 4 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

B-89

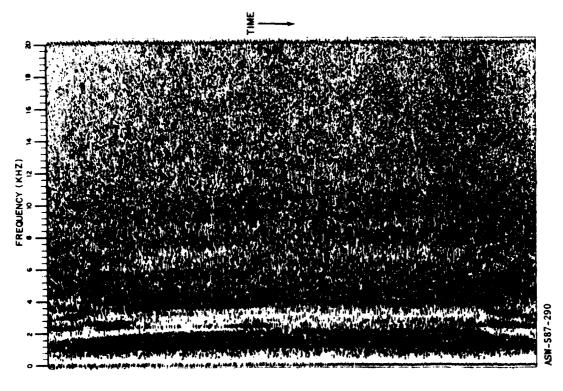
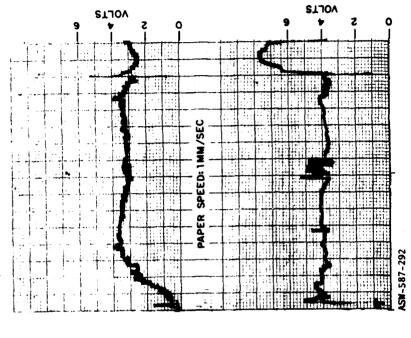


Figure B-127. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



PAPER SPEED: 1MM/SEC

\$170A

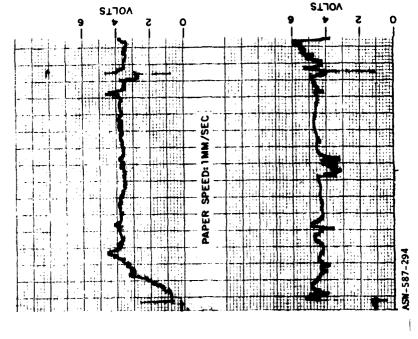
Figure B-129. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

Figure B-128. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

_į

ASW-587-291

0



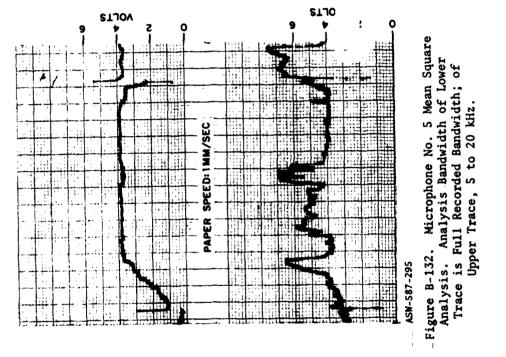
0

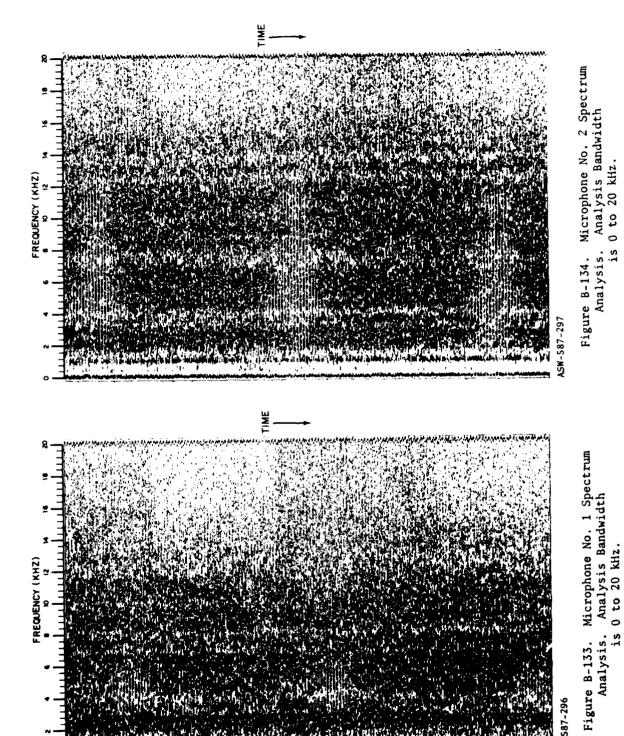
PAPER SPEED: 1MM/SEC

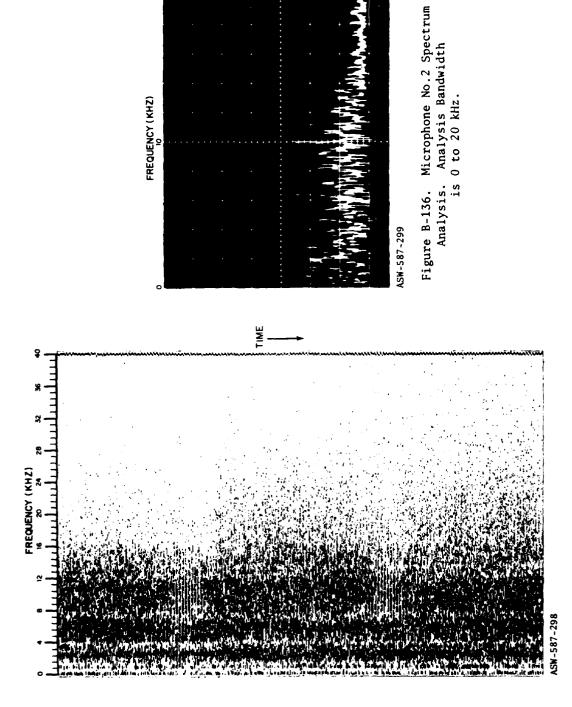
Figure B-131. Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

ASW-587-293
Figure B-130. Microphone No. 3 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

0

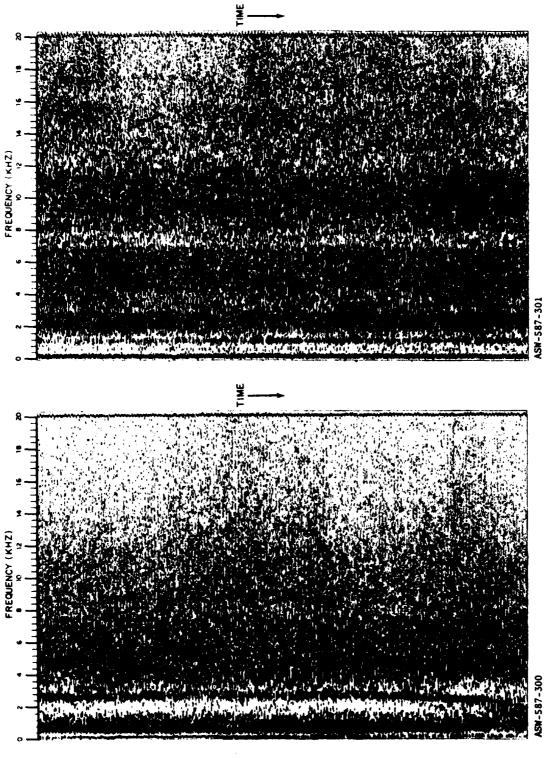






FREQUENCY (KHZ)

Figure B-135. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 40 kHz.



1

Figure B-138. Microphone No. 4 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

Figure B-137. Microphone No. 3 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

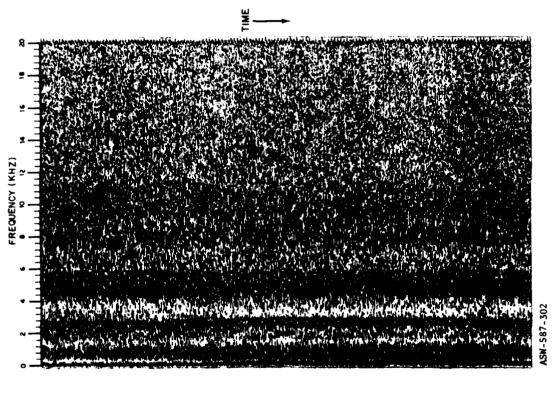
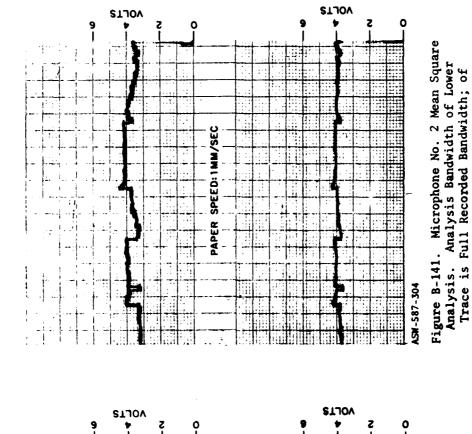


Figure B-139. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



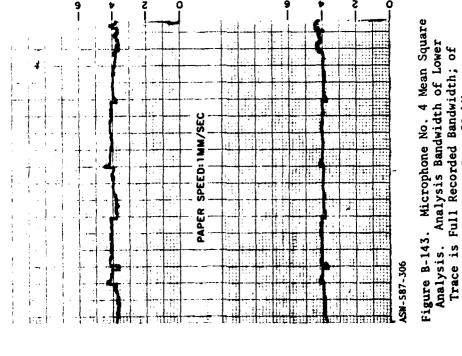
1

Figure B-140. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

Upper Trace, 5 to 20 kHz.

ASW-587-303

PAPER SPEED: 1MM/SEC



-

Upper Trace, 5 to 20 kHz.

Upper Trace, 5 to 20 kHz.

ASW-587-305

Figure B-142. Microphone No. 3 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of

PAPER SPEED: IMM/SEC

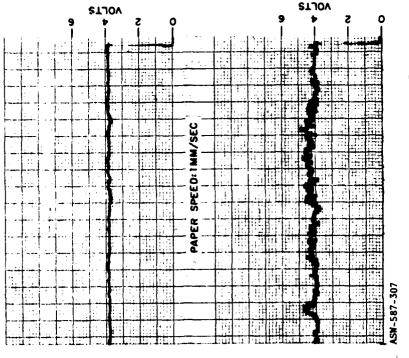


Figure B-144. Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

B.5 J-57 ENGINE, MODIFIED BURNER CAN FAILURE - 82% RPM

In order to simulate an actual burner can burn-through, the open hole in the modified burner can on the J-57 engine was masked to a 1.5-inch diameter hole and covered with a 0.062-inch thick aluminum cap. In addition, a 0.05 inch thick piece of material was fastened to the cowling. The effect of the two thicknesses of material was to simulate actual conditions. The engine was started and power was increased with flame in the can until failure occurred. The test was recorded using five microphones located in the same positions as for the closed-hole test. The purpose of this test was to compare the sound energy level of a burn-through with that of an open hole.

Analysis of the recordings made during this test run appear on pages B-103 through B-114.

B.5.1 Analysis

B.5.1.1 Sound Energy Levels

The meter readings recorded prior to and after burn-through are within 1 dB of both the closed-hole and open-hole runs for like conditions. Only microphone 4 was recorded for this test.

B.5.1.2 Spectrum Analysis

The grams clearly show the same discrete frequency lines that appeared in the closed-hole test prior to burn-through. When the burner can cap ruptured, a dark band of broadband random noise appeared. The noise subsided momentarily, then increased as the cowling cover ruptured. The intensity of the noise after cowling rupture was not as great as for the burner can cap rupture. No discrete burn-through frequencies were apparent. The major portion of the spectrum appeared below 10 kHz tapering off gradually as the frequency increased. Instrumentation microphone No. 2 data was analyzed to 40 kHz.

B.5.1.3 Mean Square Analysis

Previous tests indicated that much of the broadband random noise created by engine machinery was below 5 kHz whereas the burnthrough broadband random noise was above 5 kHz. To illustrate and confirm this assumption, instrumentation microphone No. 2 was analyzed at 2 to 20 kHz, 3 to 20 kHz, 4 to 20 kHz, and 5 to 20 kHz using raw DATA (0 to 70 kHz) analysis as a direct comparison. Burn-through was hardly discernable in the raw processed recording but became increasingly more visible as the low band frequency cutoff was raised.

B.5.2 Environmental Conditions

The test was performed at an ambient temperature of 77° F and 25% relative humidity. Microphone temperatures were as follows:

	MICROPHONE				
	1	2	3	4	5
TEMPERATURE (° F)	100	130	80 (a)	110	70 (a)

^aThe thermocouples were inaccurate below 100° F.

B.5.3 Sound Energy Level

The following table lists the sound energy level of microphone $\mbox{No.}$ 4 before and after burn-through.

Table B-13. Sound Energy Level Before and After Burn-through

	MICROPHONE No. 4			
SOUND LEVEL	BEFORE	AFTER		
RMS (mV)	78	230		
RMS (µBAR)	540	1850		
dB (a)	130	139		

^aReference = $2 \times 10^{-4} \mu BAR$

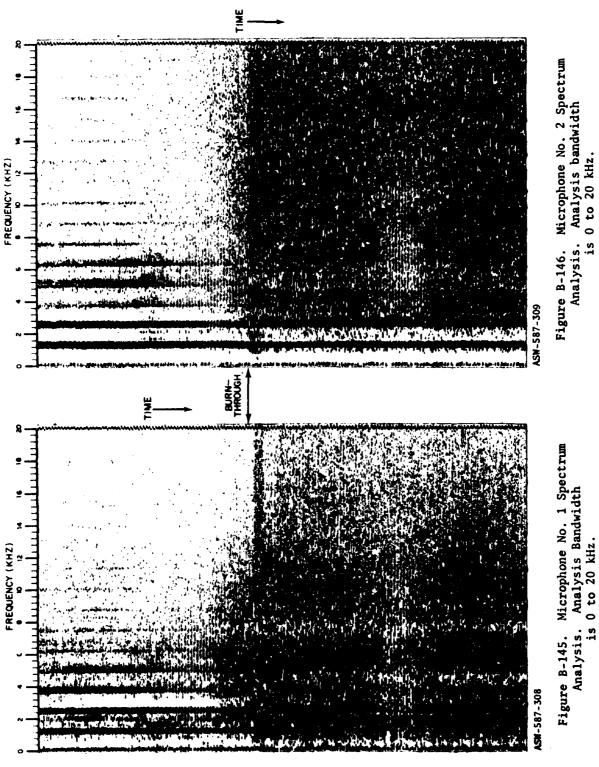
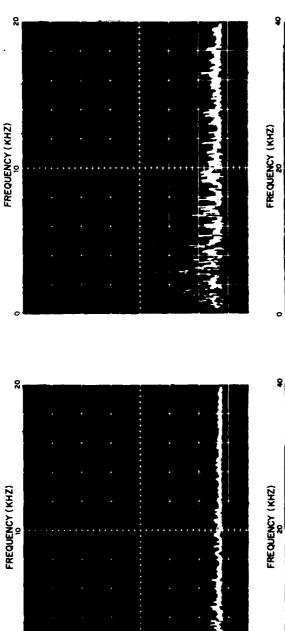
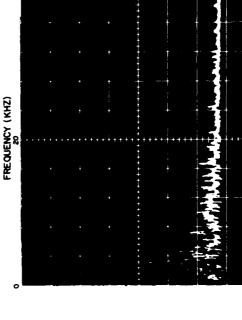


Figure B-146. Microphone No. 2 Spectrum Analysis. Analysis bandwidth is 0 to 20 kHz.



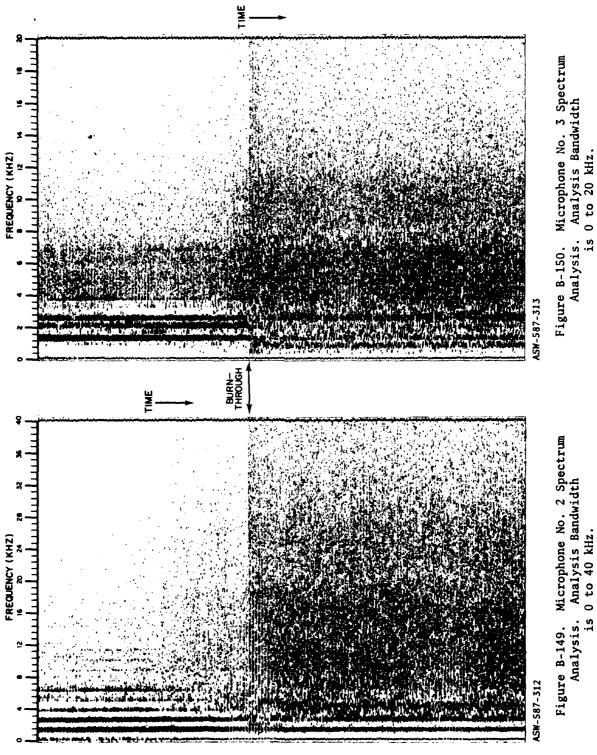


ASW-587-311

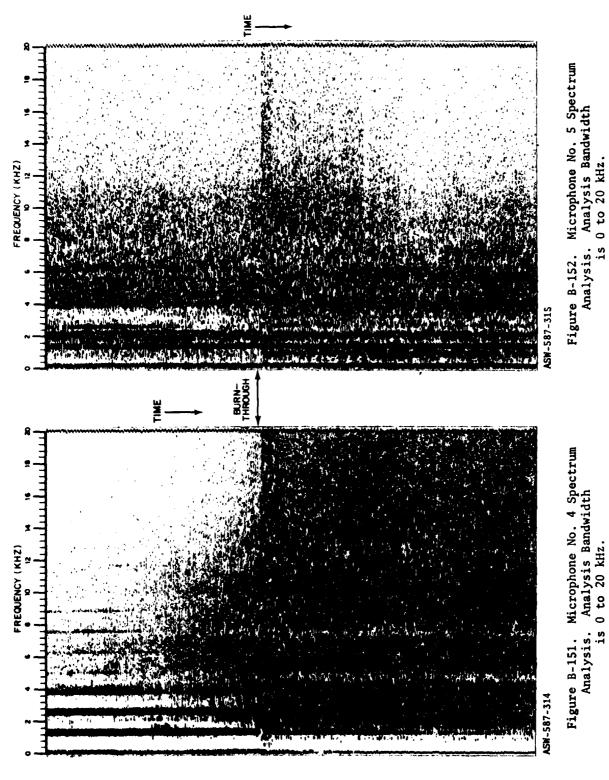
Figure B-147. Microphone No. 2 Spectrum Analysis Before Burn-through. Analysis Bandwidths are 0 to 20 kHz and 0 to 40 kHz. B

ASW-587-310

Figure B-148. Microphone No. 2 Spectrum Analysis After Burn-through. Analysis Bandwidths are 0 to 20 kHz and 0 to 40 kHz.



B-105



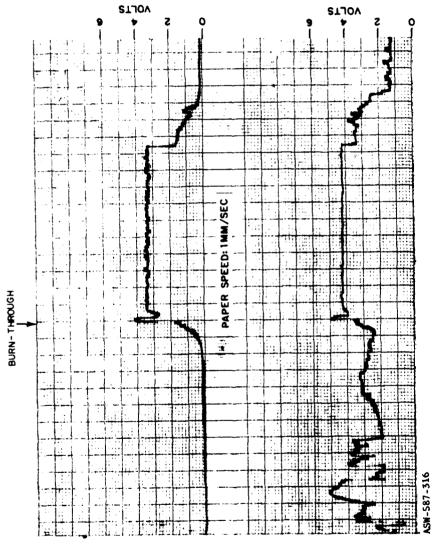


Figure B-153. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

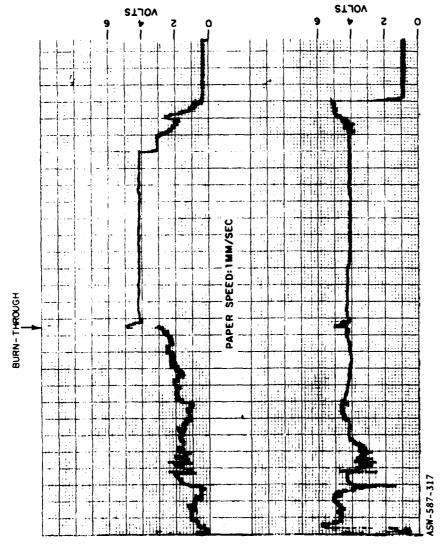


Figure B-154. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 2 to 20 kHz.

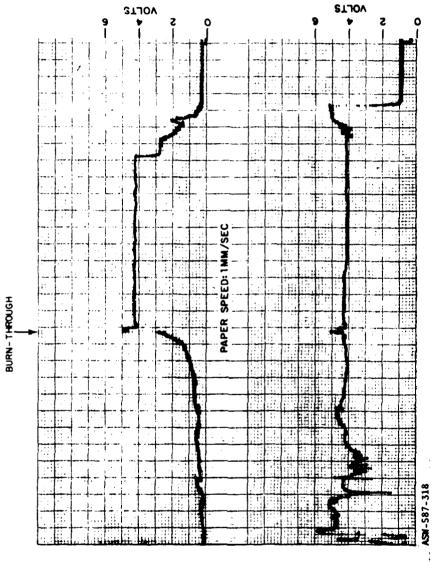
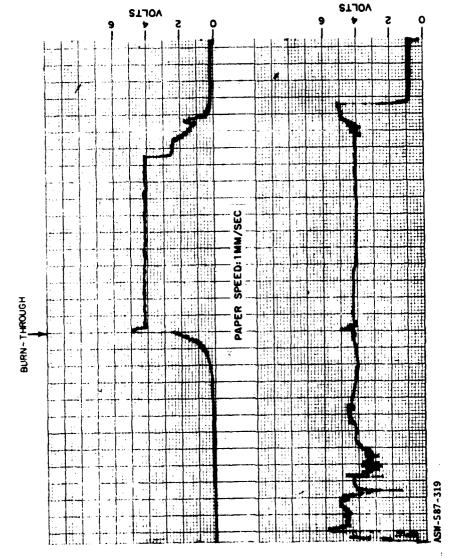


Figure B-155. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 3 to 20 kHz.

į



į

Figure B-156. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 4 to 20 kHz.

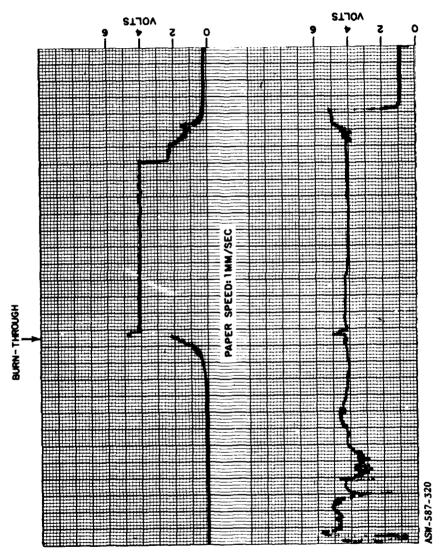
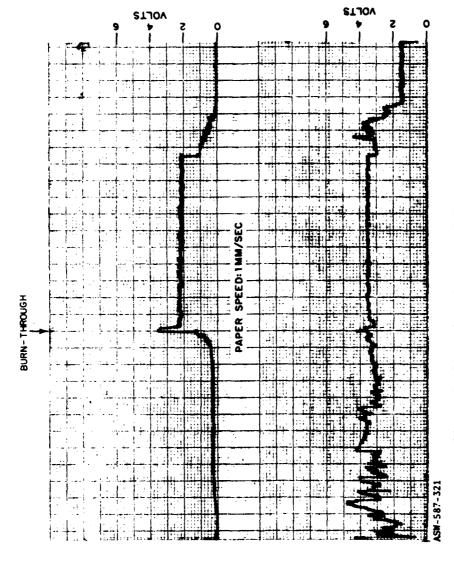


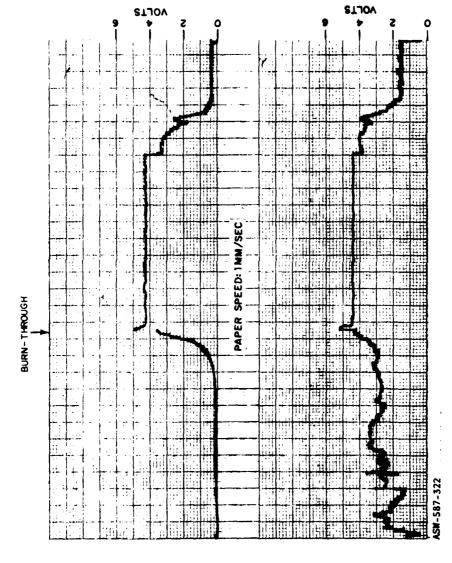
Figure B-157. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

-1



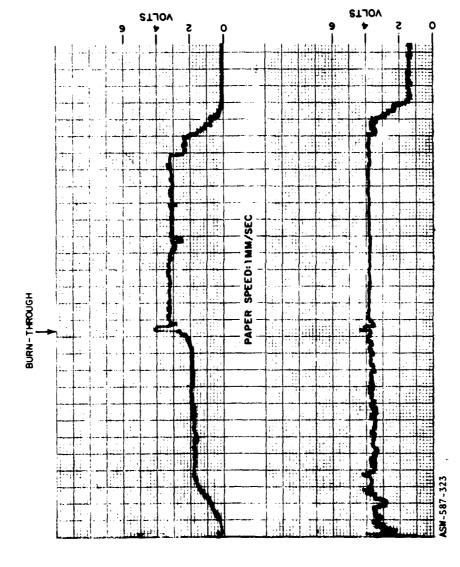
1

Figure B-158. Microphone No. 3 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.



į

Figure B-159. Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.



å,

Figure B-160. Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

B.6 J-57 ENGINE, MODIFIED BURNER CAN FAILURE - 90% RPM

A second test was run which duplicated the previous burner-can failure test except that the engine speed was increased to 90% RPM.

Analysis of the recordings made during this test run appear on pages B-117 through B-124.

B.6.1 Analysis

B.6.1.1 Sound Energy Levels

The meter readings recorded prior to burn-through are 2 dB greater than those recorded for the closed-hole test. The readings after burn-through are the same as for the 1.5 inch open-hole test.

B.6.1.2 Spectrum Analysis

Each gram was unique for the 90% RPM burn-through test. They varied not only in discrete frequency content, but also displayed the burner can and cowling ruptures in distinctly different manners. Broadband random noise also varied greatly.

B.6.1.3 Mean Square Analysis

The low frequency cutoff was varied in the same manner as the 82% RPM burn-through. The results were similar but not as vivid because of less low frequency content in the spectrum. Microphone 5, farthest from the burn-through, had greater frequency content in the spectrum and showed less change even when filtered.

B.6.2 Environmental Conditions

The test was performed at an ambient temperature of 77° F and 25% relative humidity. Microphone temperatures were as follows:

	MICROPHONE				
	1	2	3	4	5
TEMPERATURE (F)	110	130	70 (a)	110	70 (a)

^aThe thermocouples were inaccurate below 100° F.

B.6.3 Sound Energy Levels

The following table lists the sound energy level of microphone 4 before and after burn-through.

Table B-14. Sound Energy Level Before and After Burn-through

	MICROPHONE No. 4			
SOUND LEVEL	BEFORE	AFTER		
RMS (mV)	38	220		
RMS (µBAR)	300	1750		
dB (a)	124	139		

^aReference = $2 \times 10^{-4} \mu BAR$

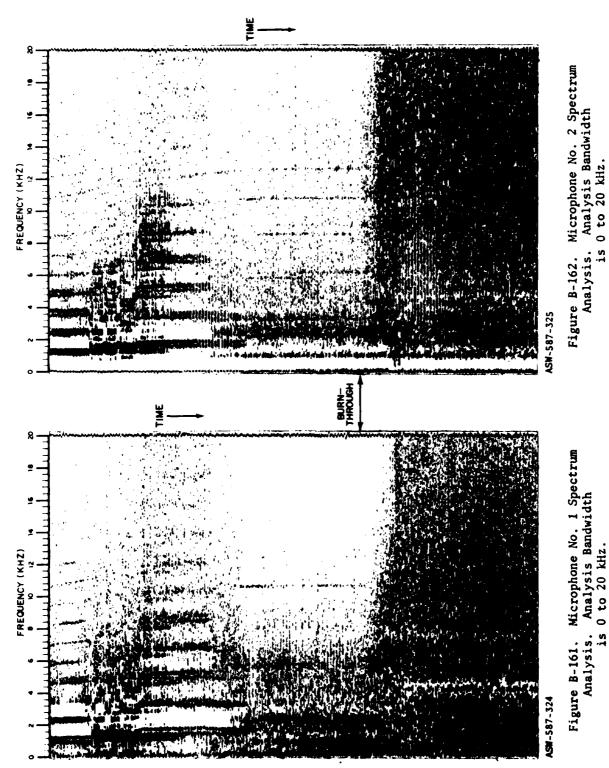
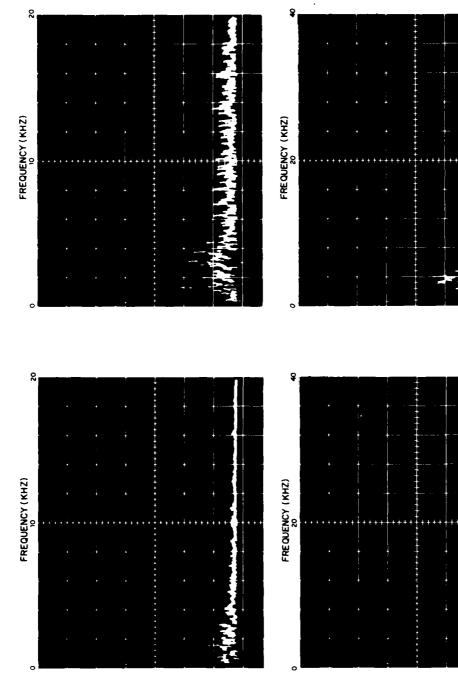


Figure B-161. Microphone No. 1 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

B-117



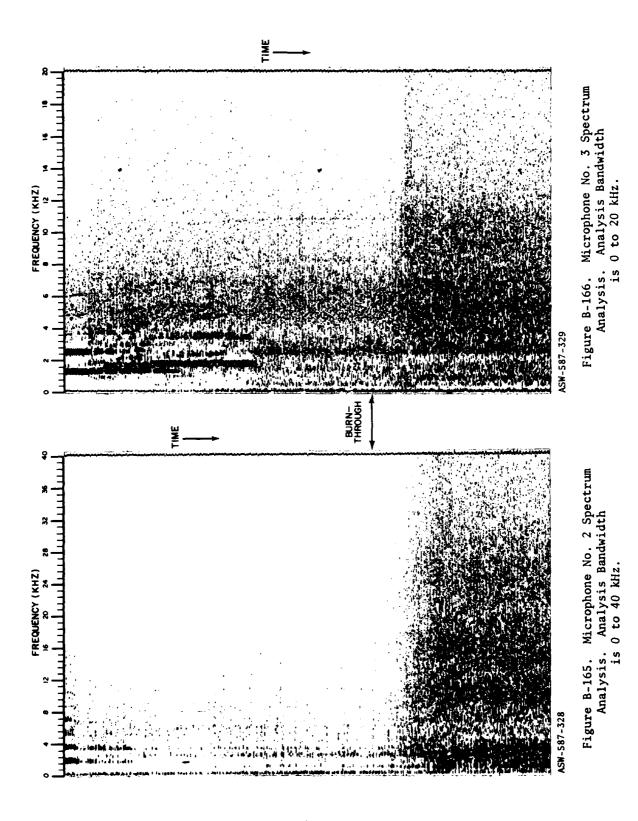
į

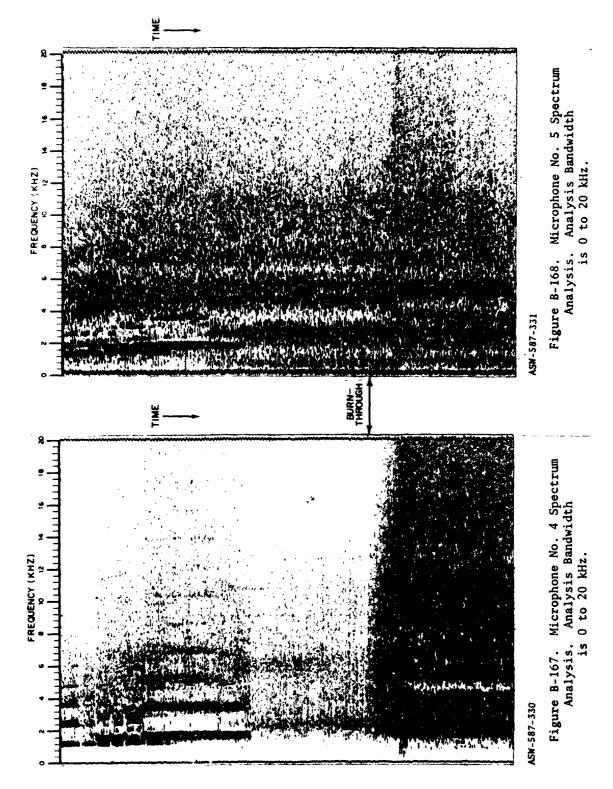
Figure B-164. Microphone No. 2 Spectrum Analysis After Burn-through. Analysis Bandwidths are 0 to 20 kHz and 0 to 40 kHz.

Figure B-163. Microphone No. 2 Spectrum Analysis Before Burn-through. Analysis Bandwidths are 0 to 20 kHz and 0 to 40 kHz.

ASW-587-326

ASW-587-327





į

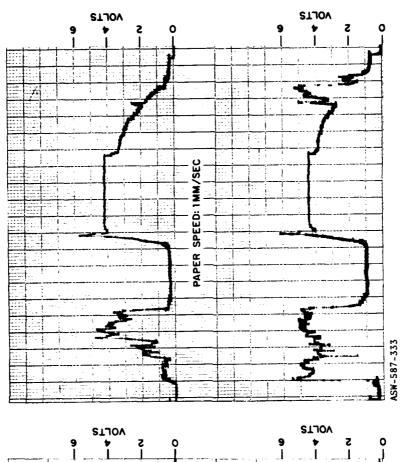
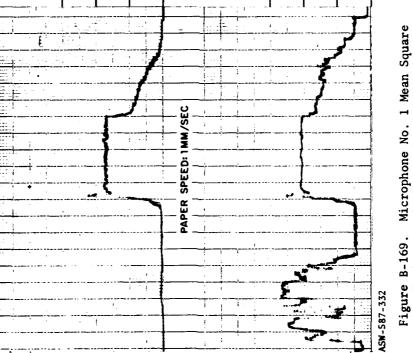
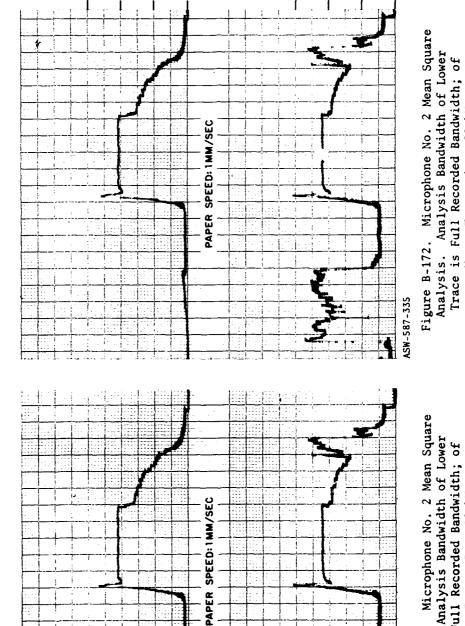


Figure B-170. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 2 to 20 kHz.



1

Figure B-169. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.



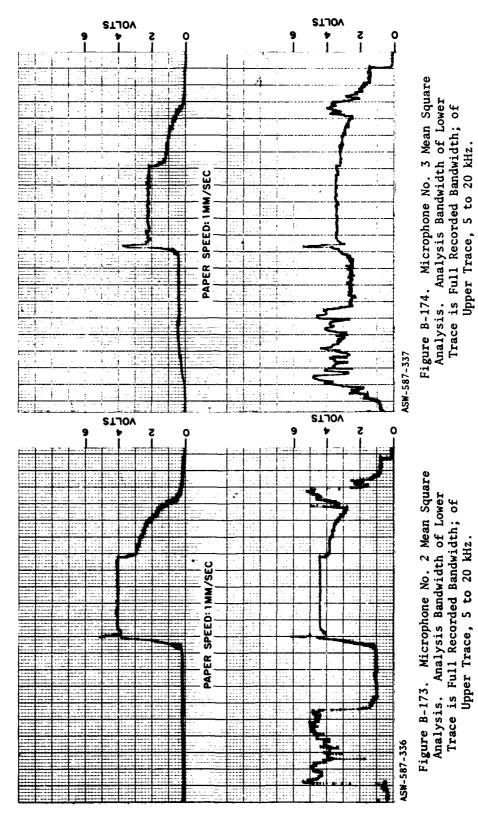
\$110V

\$TJOV

Figure B-171. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 3 to 20 kHz.

ASW-587-334

Upper Trace, 4 to 20 kHz.



1

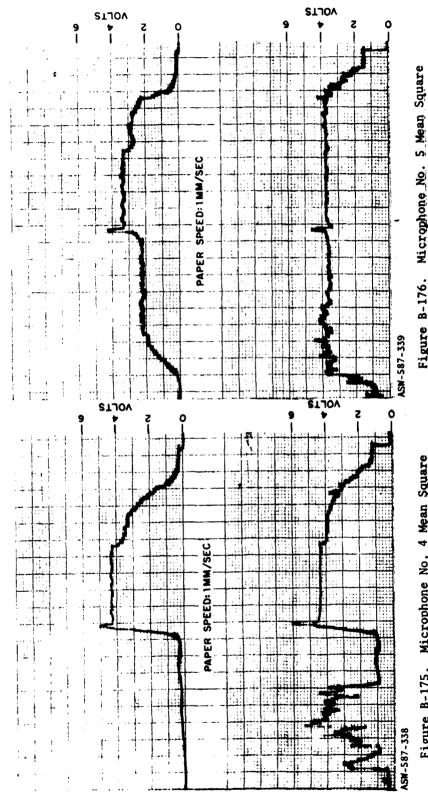


Figure B-175. Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

Figure B-176. Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

B.7 J-57 ENGINE, MODIFIED BURNER CAN FAILURE - MAXIMUM RPM

A third test was run which duplicated the previous two-burner can failure tests except that the engine speed was increased to maximum RPM.

Analysis of the recordings made during this test run appear on pages B-127 through B-134.

B.7.1 Analysis

B.7.1.1 Sound Energy Levels

The meter readings recorded prior to burn-through were 2 dB greater than those recorded for the closed-hole test. The readings after burn-through were the same as for the 1.5 inch open-hole test.

B.7.1.2 Spectrum Analysis

All grams showed the burn-through except the microphone 5 gram. The broadband random noise was so dense that point of burn-through was not clearly discernible. This microphone was farthest from the burn-through.

B.7.1.3 Mean Square Analysis

The low frequency cutoff was varied in the same manner as for the 82% RPM burn-through. The results were similar to the 90% RPM test except that, as noted in the spectrum analysis, microphone 5 recordings did not clearly depict the burn-through.

B.7.2 Environmental Conditions

The test was performed at an ambient temperature of 70° F and 37% relative humidity. Microphone temperatures were as follows:

	MI CROPHONE				
	1	2	3	4	5
TEMPERATURE (°F)	100	160	70 (a)	100	60 (a)

^aThe thermocouples were inaccurate below 100° F.

B.7.3 Sound Energy Levels

The following table lists the sound energy level of microphone 4 before and after burn-through.

Table B-15. Sound Energy Level Before and After Burn-through

	MICROPHONE No. 4			
SOUND LEVEL	BEFORE	AFTER		
RMS (mV)	47	235		
RMS (µBAR)	380	1900		
dB (a)	125	139		

^aReference = $2 \times 10^{-4} \mu BAR$

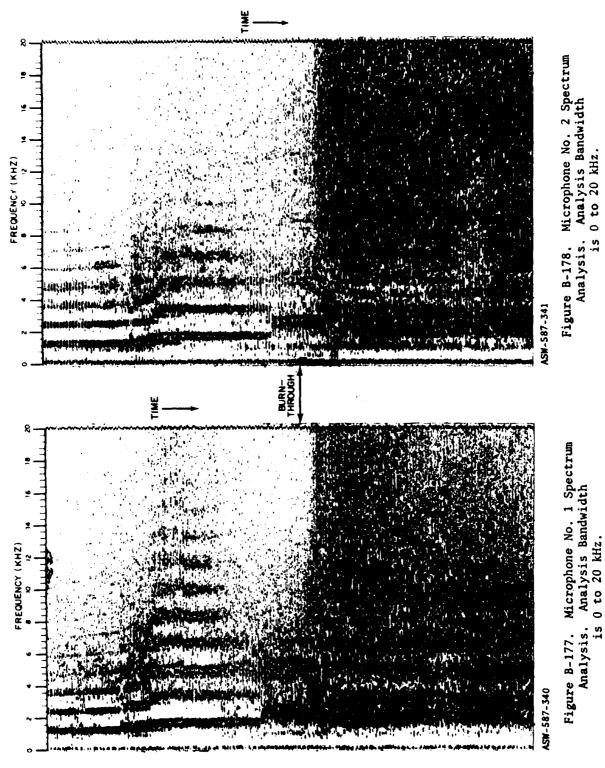


Figure B-178. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

B-127

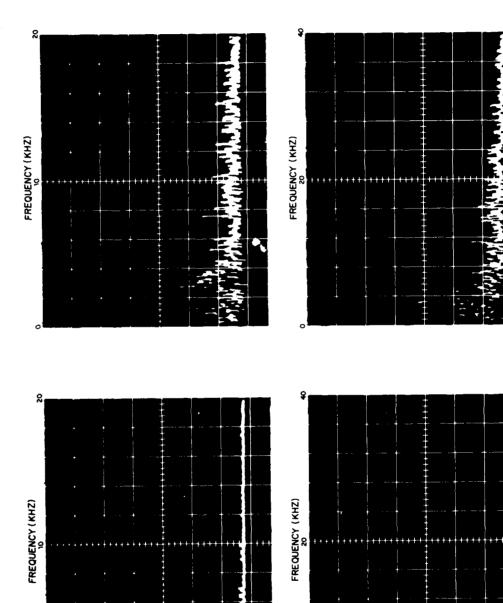


Figure B-179. Microphone No. 2 Spectrum Analysis Before Burn-through Analysis Bandwidths are 0 to 20 kHz and 0 to 40 kHz.

ASW-587-342

Figure B-180. Microphone No. 2 Spectrum Analysis After Burn-through. Analysis Bandwidths are 0 to 20 kHz and 0 to 40 kHz.

ASW-587-343

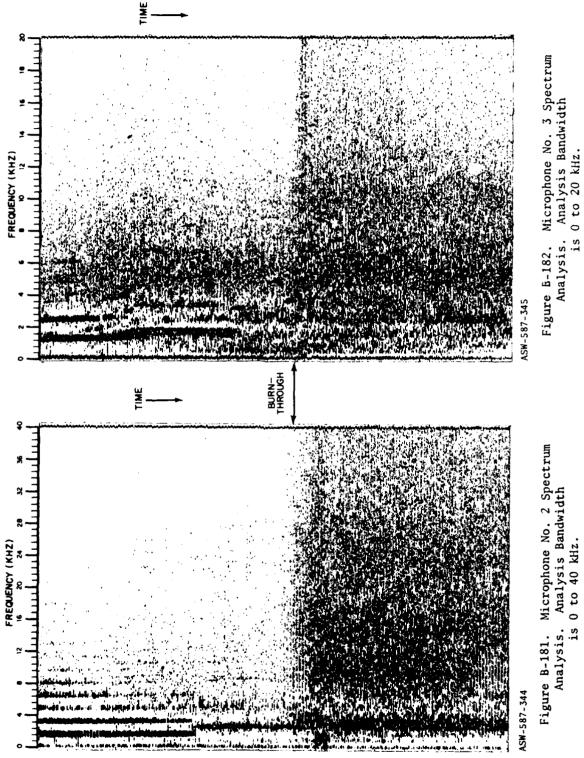
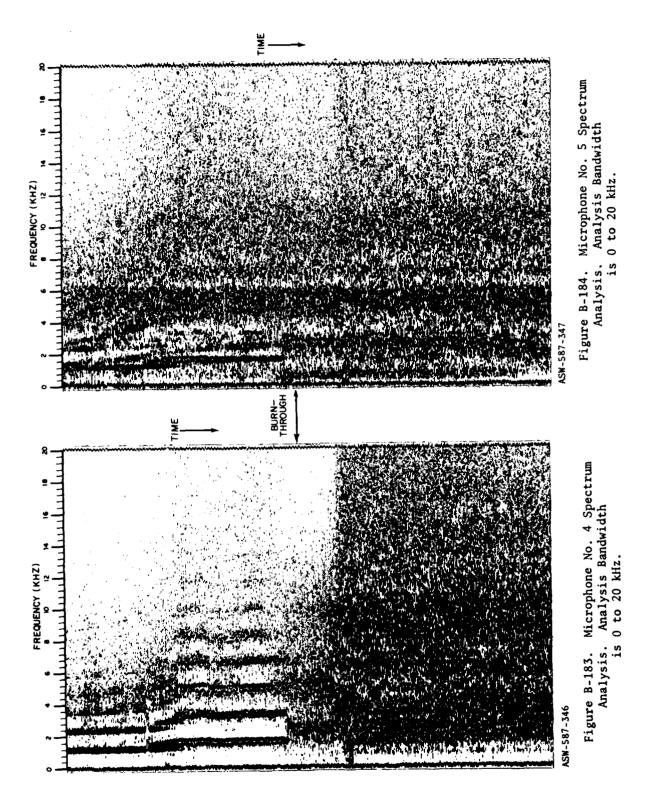
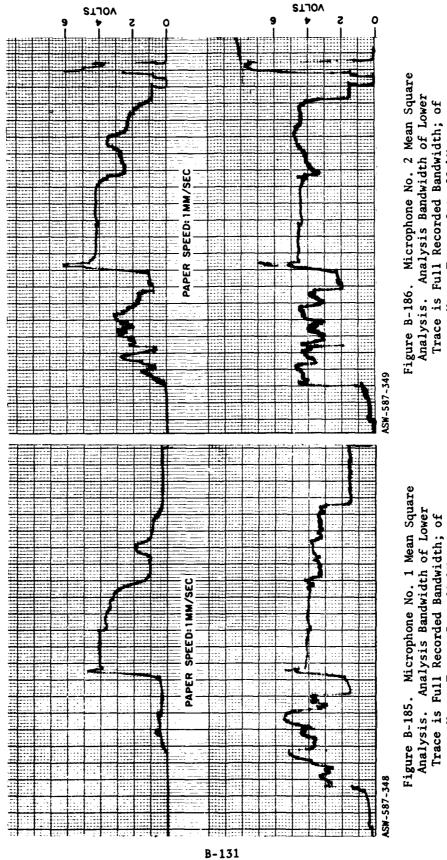


Figure B-182. Microphone No. 3 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.





ĺ

Figure B-186. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 2 to 20 kHz.

Upper Trace, 5 to 20 kHz.

A & . .

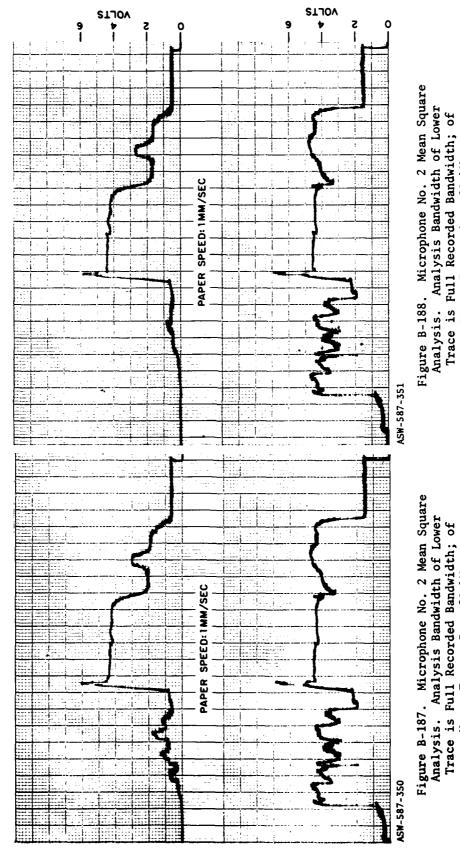


Figure B-188. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 4 to 20 kHz.

Upper Trace, 3 to 20 kHz.

B-132

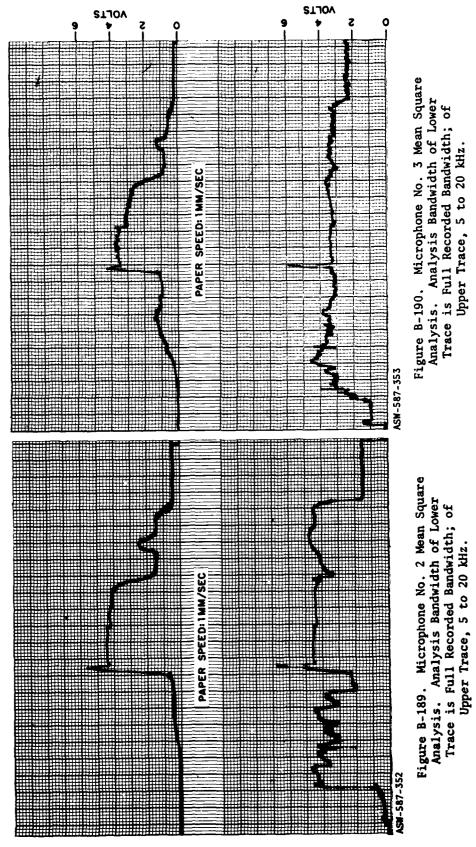


Figure B-190. Microphone No. 3 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

からなり、 天皇の

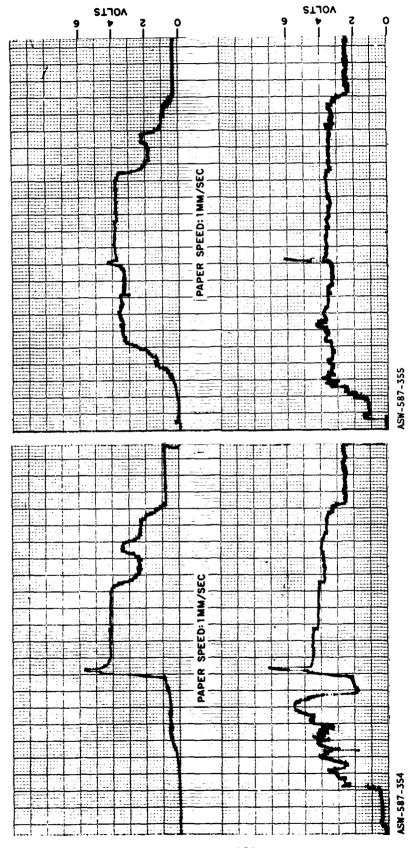


Figure B-192. Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. Figure B-191. Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

さらなる 味噌の

B-134

1

B.8 J-57 ENGINE, MODIFIED BURNER CAN FAILURE

This test was similar to the previous three burn-through tests except that instrumentation microphone No. 2 was replaced by a microphone of the same type as microphones 1, 3, 4, and 5.

Analysis of the recordings made during this test run appear on pages B-137 through B-144.

B.8.1 Analysis

B.8.1.1 Sound Energy Levels

The meter readings prior to burn-through vary from the no hole test, but it is felt that variations are due to recalibration of equipment prior to this test. The meter readings after burn-through also vary from previous 1.5-inch open-hole tests, again probably due to recalibration.

B.8.1.2 Spectrum Analysis

All grams show the burn-through and are similar to previous burn-through test grams.

B.8.1.3 Mean Square Analysis

All recordings show the burn-through. Microphone 5, the farthest from the burn-through, was again not as clear as the other microphones.

B.8.2 Environmental Conditions

The test was performed at an ambient temperature of $75^{\circ}F$ and 82% relative humidity.

B.8.3 Sound Energy Levels

The following tables list the sound energy level of the five microphones before and after burn-through.

Table B-16. Sound Energy Levels Before Burn-through

	MICROPHONE				
SOUND LEVEL	1	2	3	4	5
RMS (mV)	37	39	62	48	49
RMS (µBAR)	300	310	500	380	390
dB (a)	123	124	127	126	126

^aReference = $2 \times 10^{-4} \mu BAR$

Table B-17. Sound Energy Levels After Burn-through

	MICROPHONE				
SOUND LEVEL	1	2	3	4	5
RMS (mV)	170	230	105	235	72
RMS (µBAR)	1370	1820	85	1900	580
dB (a)	137	139	132	139	129

^aReference = $2 \times 10^{-4} \mu BAR$

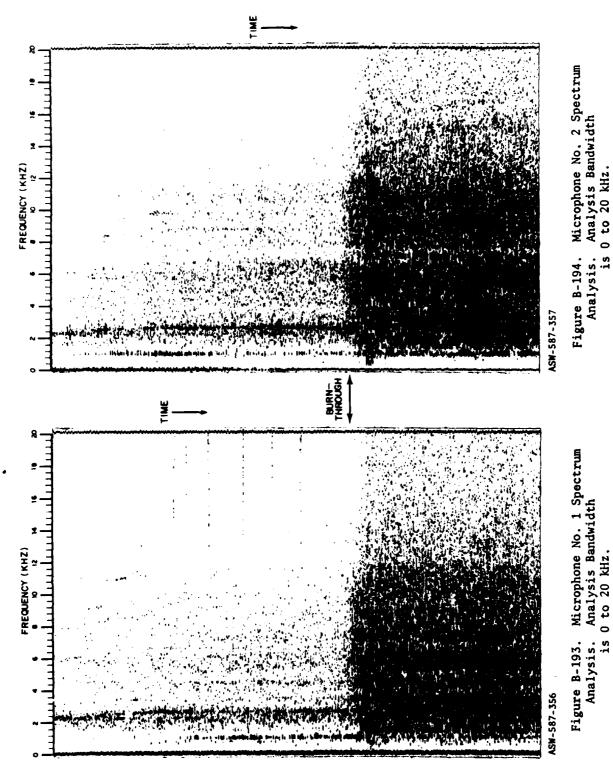
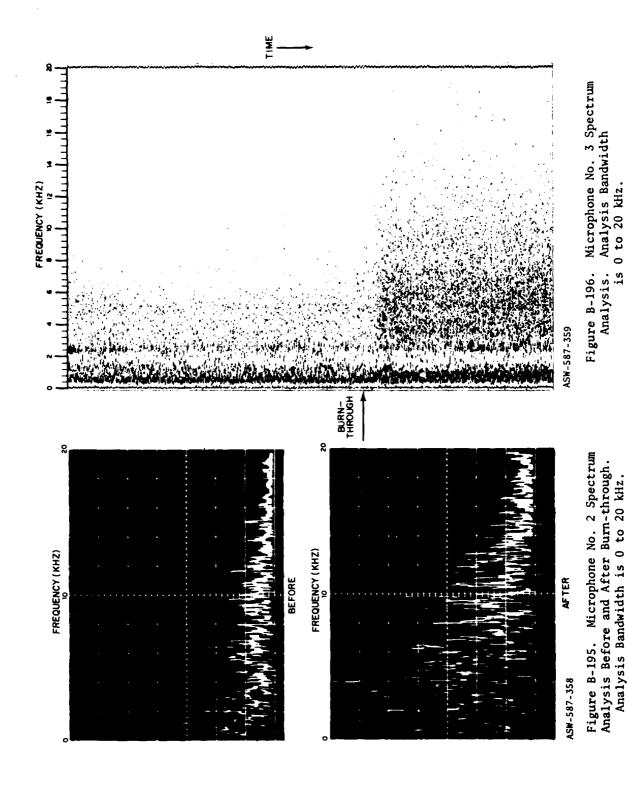
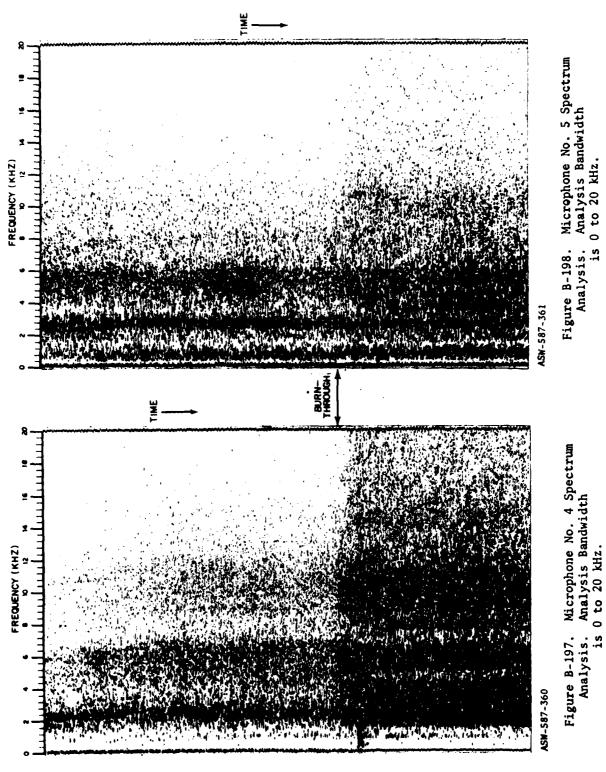
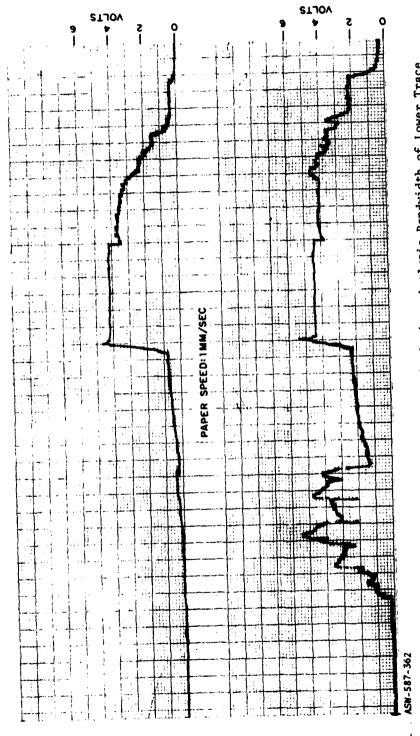


Figure B-194. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

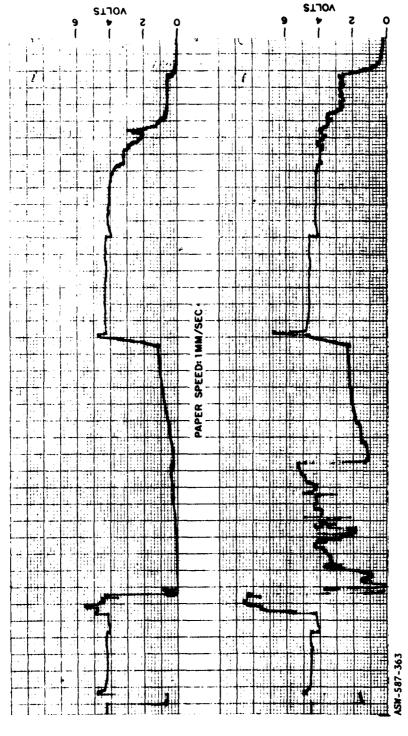




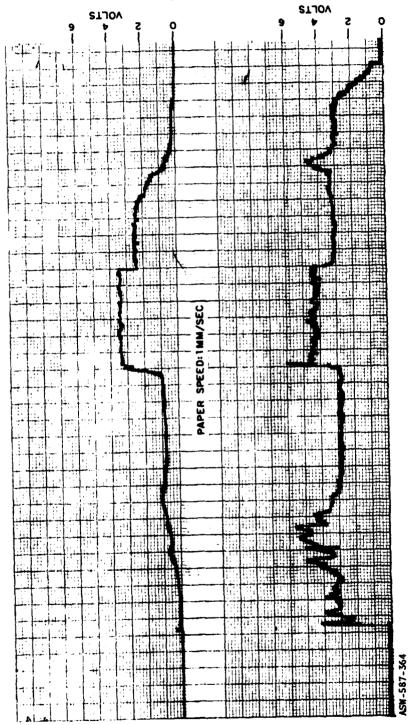
B-139



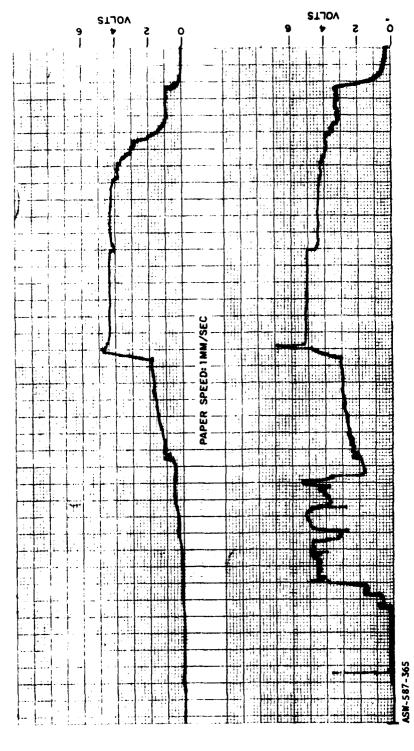
Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. Figure 8-199.



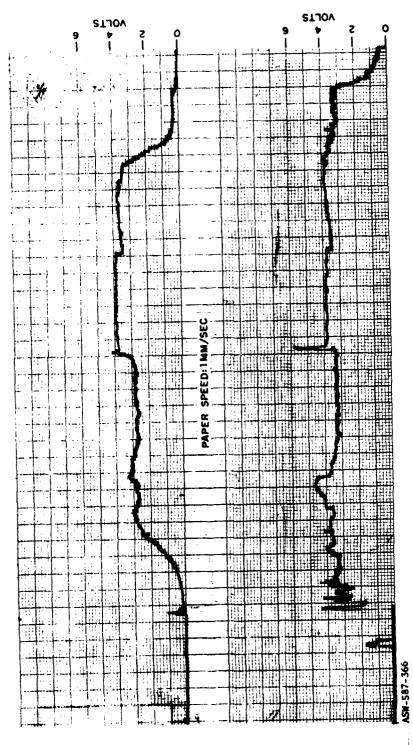
Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. Figure B-200.



Analysis Bandwidth of Lower Trace Microphone No. 3 Mean Square Analysis. Analysis Bandwidth is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. Figure B-201.



Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. Figure B-202.



Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. Figure B-203.

APPENDIX C

COMBINED J-47 and J-57 ENGINE TESTS

C.1 J-47 ENGINE AT MAXIMUM RPM, J-57 PORT ENGINE QUIET

A series of tests were developed to determine the interference from other engines in close proximity to the engine under test. Five microphones were placed on the J-57 port engine in the same locations as for appendix B tests. The J-47 engine was run up to maximum RPM and the output of the microphones recorded.

Analysis of the recordings made during this test run appear on pages C-3 through C-10.

C.1.1 Analysis

C.1.1.1 Sound Energy Levels

The sound energy levels were very low for this test. Microphones 3 and 5 showed the highest reading, probably due to their proximity to a partially open hatch and an engine starter opening. Microphones 1, 2, and 4 were mounted in an area which was tightly cowled.

C.1.1.2 Spectrum Analysis

Grams produced from microphone 3 and 5 data showed small amounts of low frequency random noise while grams produced from microphones 1, 2, and 4 data showed very little or none. This data correlates with the sound energy levels.

C.1.1.3 Mean Square Analysis

Recordings produced from microphone 3 and 5 data contain low frequency spectrum all of which is below 5 kHz. The other microphone recordings show only small amounts of energy.

C.1.2 Environmental Conditions

The test was performed at an ambient temperature of 75° F and 68% relative humidity.

C.1.3 Sound Energy Levels

The following table lists the sound energy levels of the five microphones for this test.

Table C-1. Microphone Sound Energy Levels

SOUND LEVEL	MI CROPHONE					
	1	2	3	4	5	
RMS (mV)	10	9	24	12	16	
RMS (µBAR)	80	72	190	96	128	
dB (a)	112	111	120	114	116	

^aReference = $2 \times 10^{-4} \mu BAR$

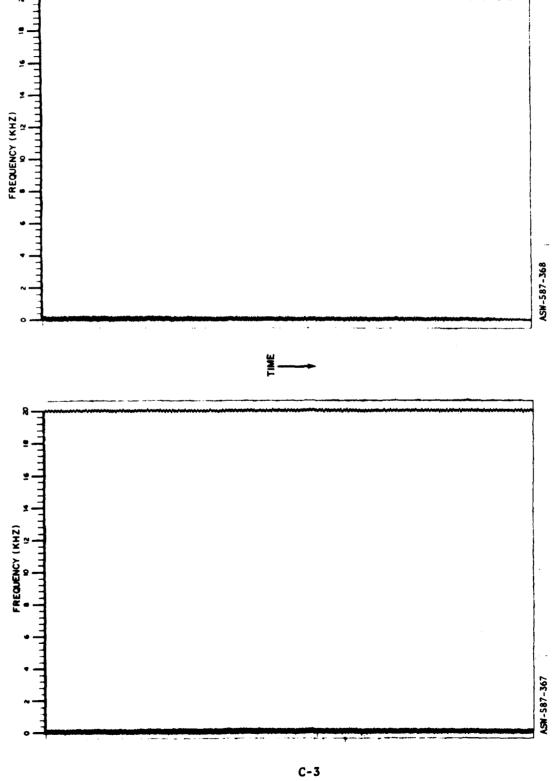
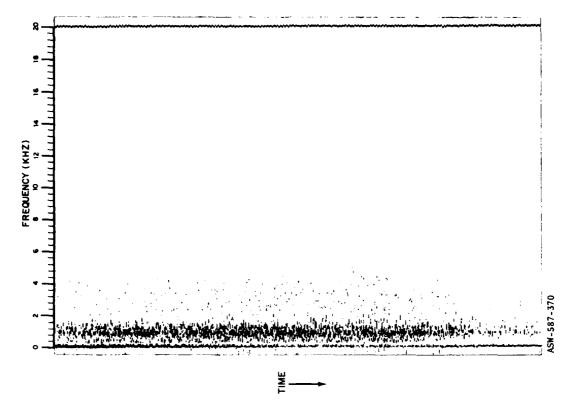


Figure C-2. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

Figure C-1. Microphone No. 1 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



FREQUENCY (KHZ)

Figure C-3. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

ASW-587-369

Figure C-4. Microphone No. 3 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

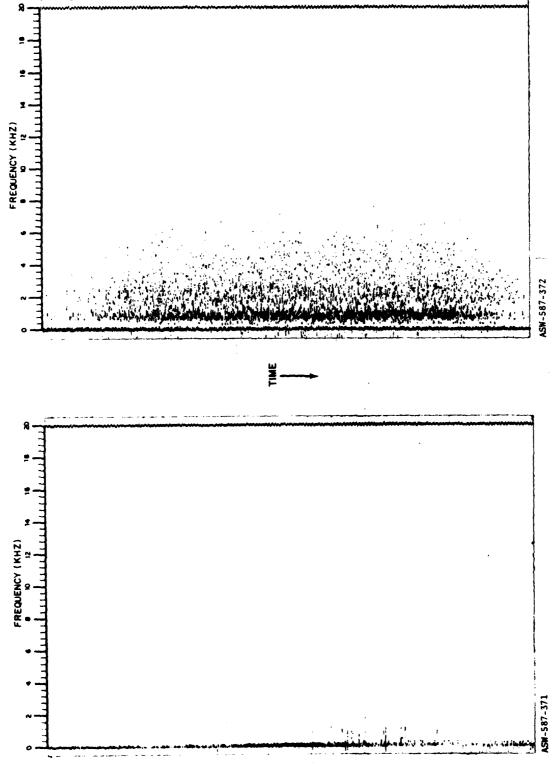


Figure C-6. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

Figure C-5. Microphone No. 4 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

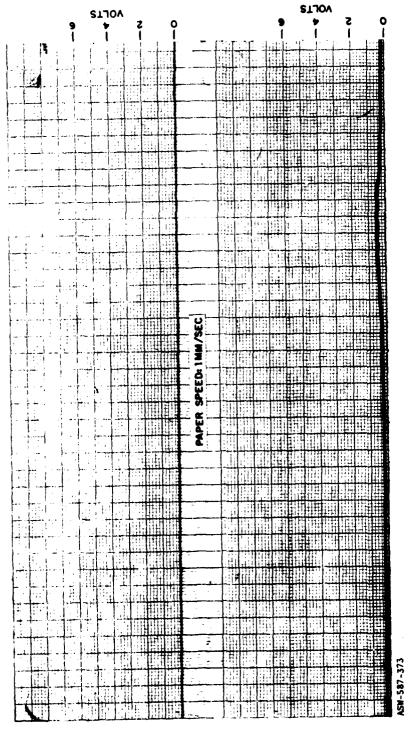
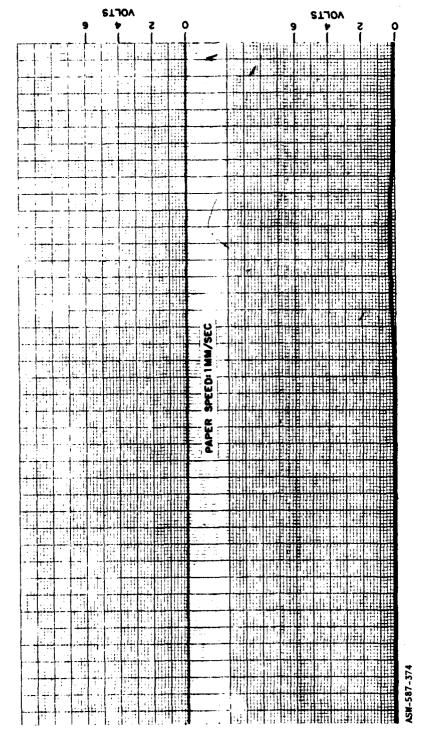
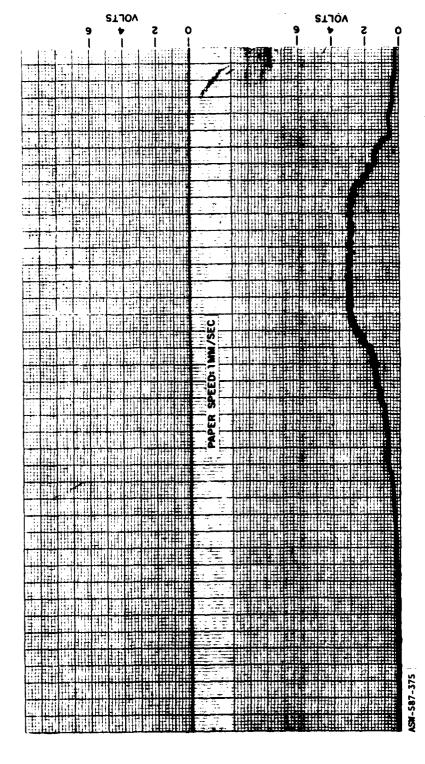


Figure C-7. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.



Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. Figure C-8.



Microphone No. 3 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. Figure C-9.

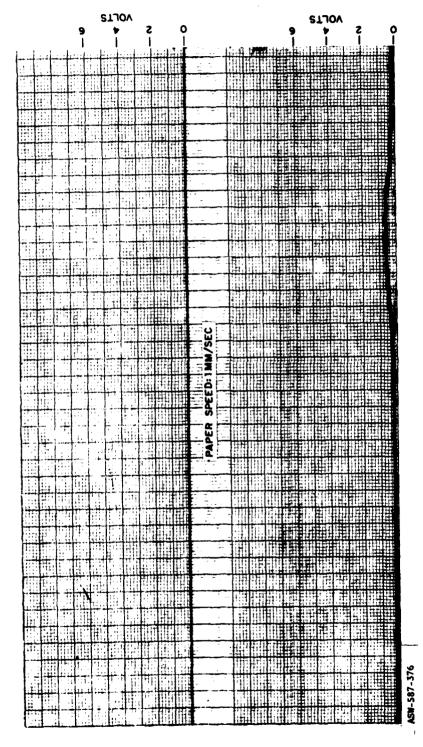
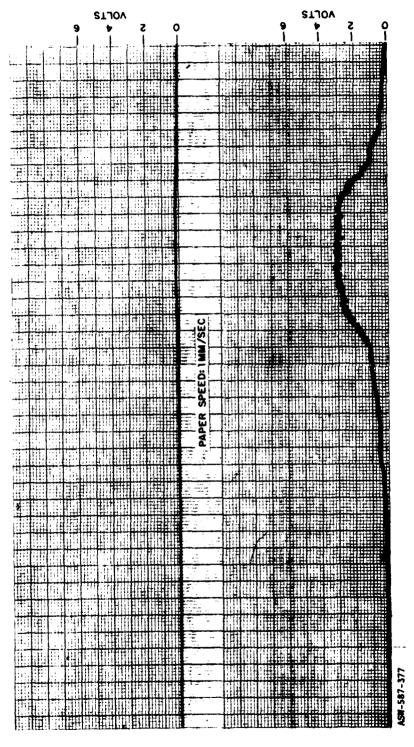


Figure C-10. Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.



Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. Figure C-11.

C.2 J-57 STARBOARD ENGINE AT MAXIMUM RPM, J-57 PORT ENGINE QUIET

A second test to determine the effect of external sound sources was run with the J-57 starboard engine running at maximum speed and the J-57 port engine quiet. The same test arrangement was utilized for this test as for the previous test.

Analysis of the recordings made during this test run appear on pages C-12 through C-16.

C.2.1 Analysis

C.2.1.1 Sound Energy Levels

The meter readings for this test were the lowest of all tests. Microphones 3 and 5, which had the highest levels in previous tests, had the highest levels in this test.

C.2.1.2 Spectrum Analysis

Microphone 3 and 5 data analysis grams show low frequency lines and some random noise. Microphone 3 has a discrete line at 1500 Hz and microphone 5 a line at 2000 Hz. All other grams are blank.

C.2.1.3 Mean Square Analysis

 $\,$ Microphone 3 and 5 recordings show small changes in amplitude. All of the spectrum was below 5 kHz.

C.2.2 Environmental Conditions

The test was performed at an ambient temperature of 75° F and 68% relative humidity.

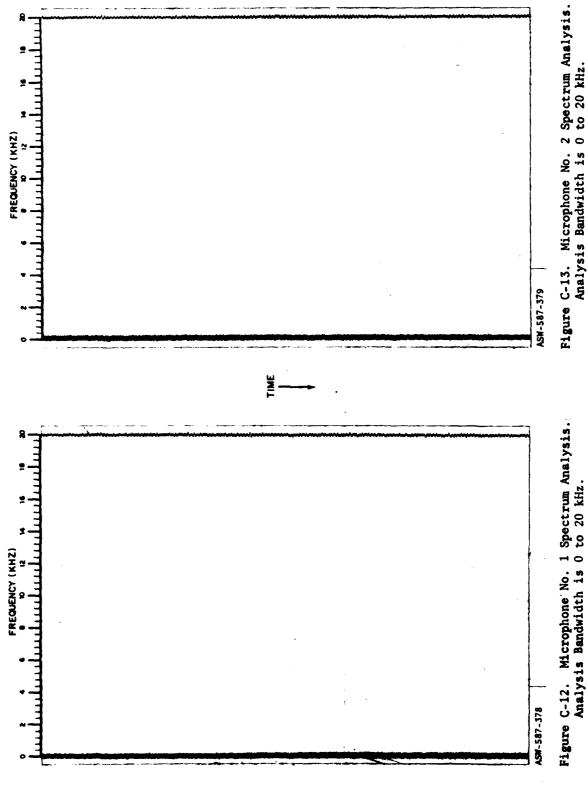
C.2.3 Sound Energy Levels

The following table lists the sound energy levels of the five microphones for this test.

MICROPHONE SOUND LEVEL 2 4 5 RMS (mV) 3 6 3 4 24 32 RMS (µBAR) 24 16 48 98 108 102 104 102 dB (a)

Table C-2. Microphone Sound Energy Levels

^aReference = $2 \times 10^{-4} \mu BAR$



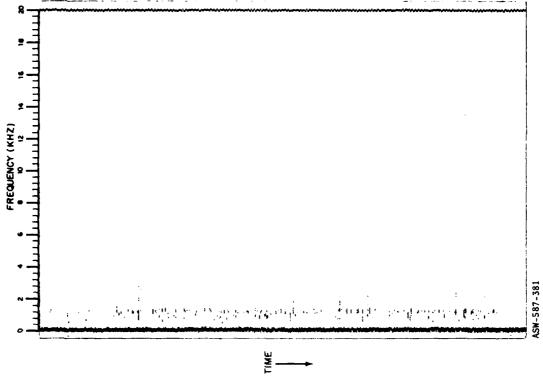


Figure C-14. Microphone No. 2 Spectrum Analysis.
Analysis Bandwidth is 0 to 20 kHz.

ASW-587-380

Figure C-15. Microphone No. 3 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

FREQUENCY (KHZ)

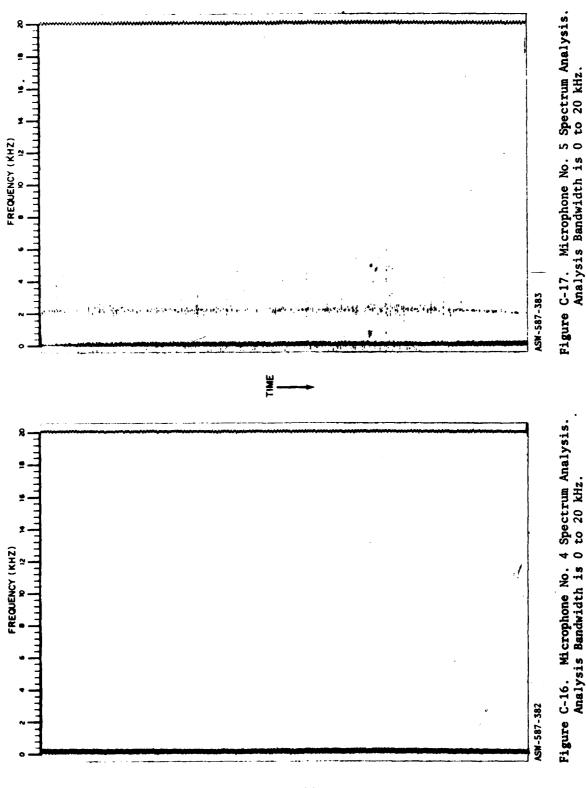


Figure C-17. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

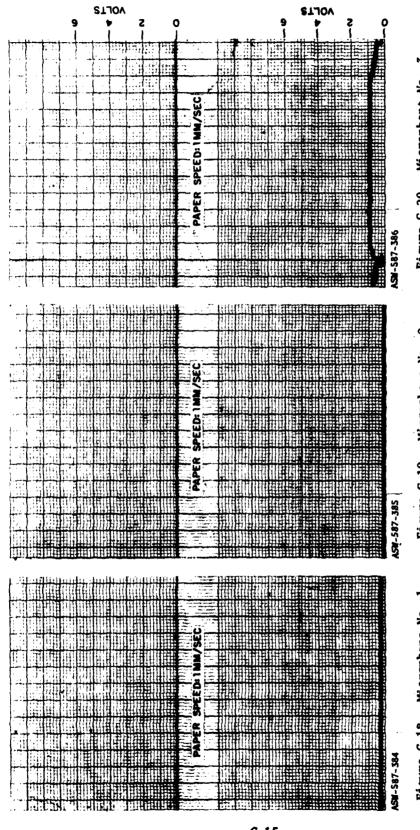
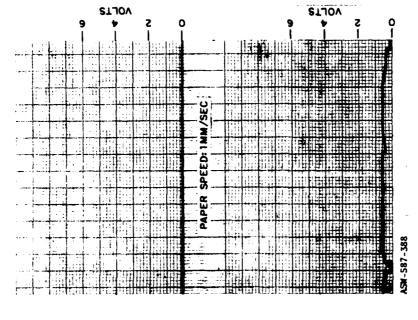


Figure C-18. Microphone No. 1
Mean Square Analysis.
Analysis Bandwidth of Lower
Trace is Full Recorded
Bandwidth; of Upper
Trace, 5 to 20 kHz.

Figure C-19. Microphone No. 2
Mean Square Analysis.
Analysis Bandwidth of Lower
Trace is Full Recorded
Bandwidth; of Upper
Trace, 5 to 20 kHz.

Figure C-20. Microphone No. 3
Mean Square Analysis.
Analysis Bandwidth of Lower
Trace is Full Recorded
Bandwidth; of Upper
Trace, 5 to 20 kHz.



o

PAPER SPEED: IMM/SEC

VOLTS

1

1

1

Figure C.22. Microphone No. 5
Mean Square Analysis.
Analysis Bandwidth of Lower
Trace is Full Recorded
Bandwidth; of Upper
Trace, 5 to 20 kHz.

Figure C-21. Microphone No. 4
Mean Square Analysis.
Analysis Bandwidth of Lower
Trace is Full Recorded
Bandwidth; of Upper
Trace, 5 to 20 kHz,

The state of the s

YOLTS

0

ASM-587-387

C.3 J-47 ENGINE AT MAXIMUM RPM, J-57 PORT ENGINE BURN-THROUGH

A final test was run with the J-47 engine running at maximum speed and the modified burner can on the J-57 engine capped and run to maximum RPM to produce a burn-through. All microphone locations and burner-can modifications were the same as for the burn-through tests in Appendix B.

Analysis of the recordings made during this test run appear on pages C-19 through C-26.

C.3.1 Analysis

C.3.1.1 Sound Energy Levels

Readings taken prior to burn-through were higher on microphones 3, 4, and 5. Data from the previous interference tests indicate that some of the increase may be due to the J-47 engine. There was some change in microphone 3 and 5 readings after burn-through but was insignificant and, as noted above, may be contributed to external engine noise.

C.3.1.2 Spectrum Analysis

The grams show no change from previous burn-through tests on this engine. (Refer to Appendix B.)

C.3.1.3 Mean Square Analysis

The recordings are similar to those in Appendix B, which were analyzed from similar data.

C.3.2 Environmental Conditions

The test was performed at an ambient temperature of 75° F and 68% relative humidity.

C.3.3 Sound Energy Levels

The following tables list the sound energy levels of the five microphones before and after burn-through.

Table C-3. Sound Energy Levels Before Burn-through

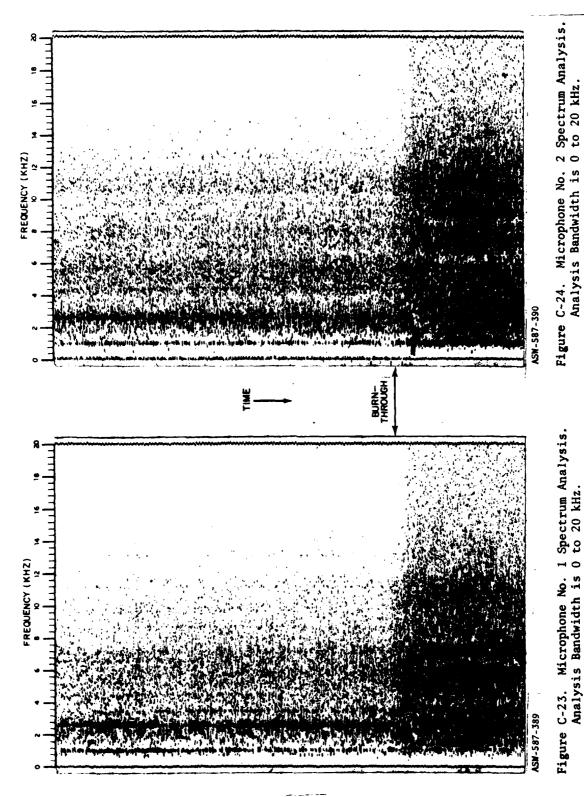
SOUND LEVEL	MICROPHONE					
	1	2	3	4	5	
RMS (mV)	44	49	61	56	50	
RMS (µBAR)	350	390	490	450	400	
dB (a)	125	126	128	127	126	

aReference = $2 \times 10^{-4} \mu BAR$

Table C-4. Sound Energy Levels After Burn-through

SOUND LEVEL	MICROPHONE					
	1	2	3	4	5	
RMS (mV)	170	230	110	230	70	
RMS (µBAR)	1370	1820	880	1820	560	
dB (a)	137	139	133	139	129	

^aReference = $2 \times 10^{-4} \mu BAR$



C-19

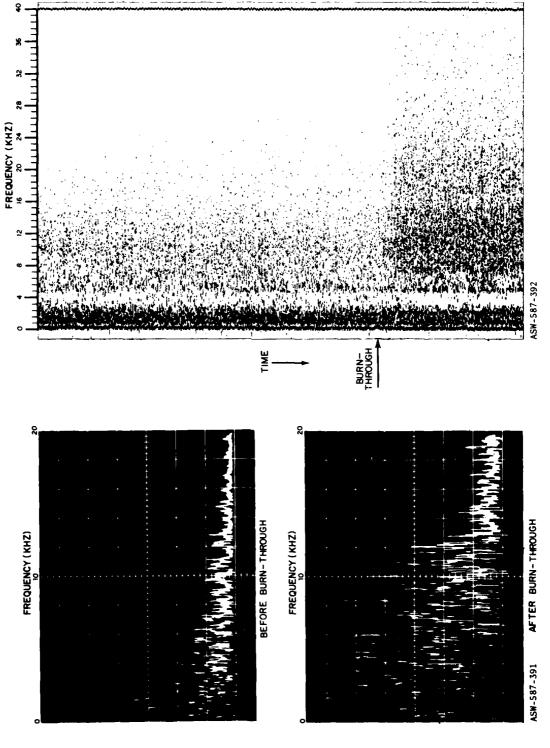


Figure C-25. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

Figure C-26. Microphone No. 3 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

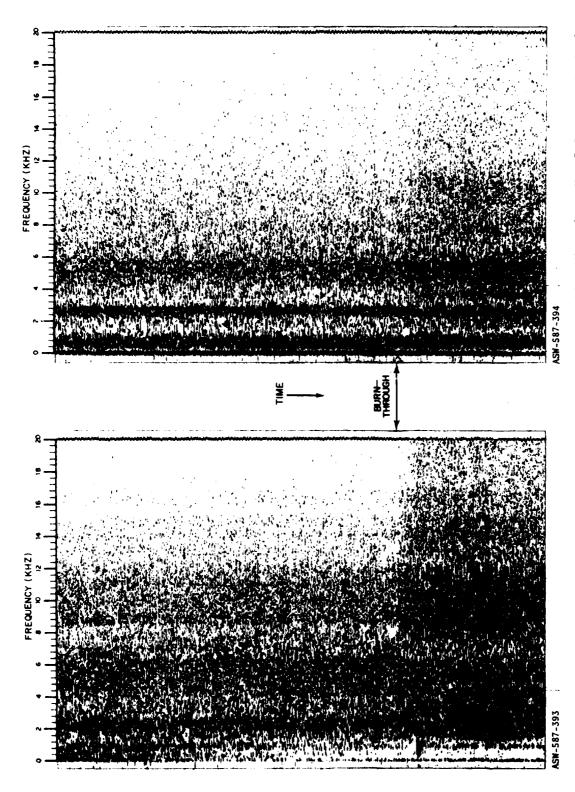


Figure C-27. Microphone No. 4 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

Figure C-28. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

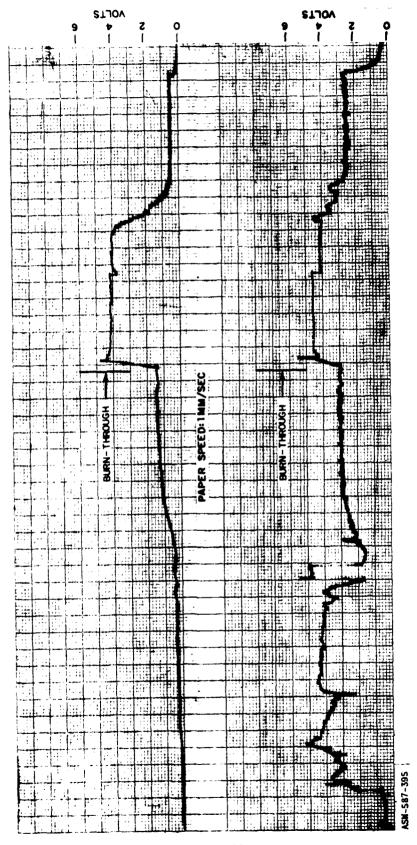


Figure C-29. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

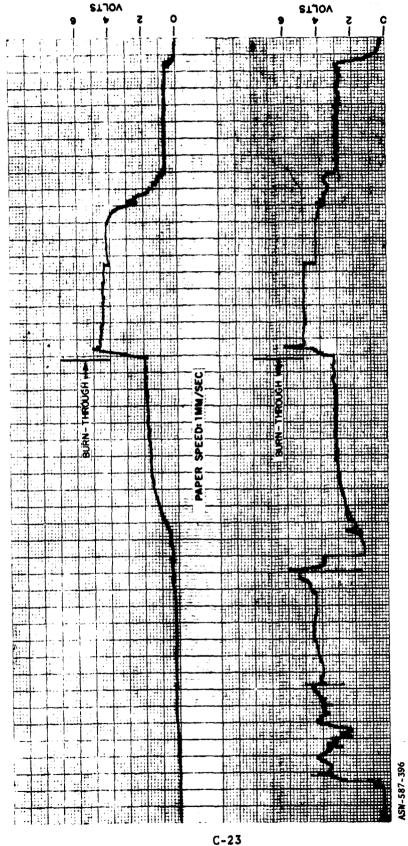


Figure C-30. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

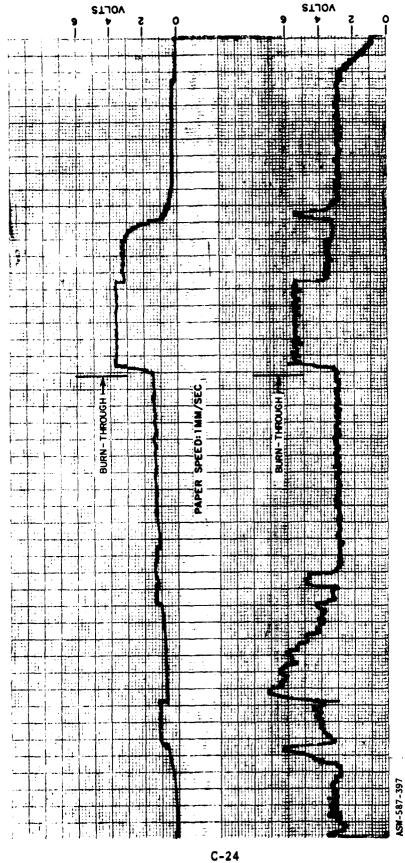
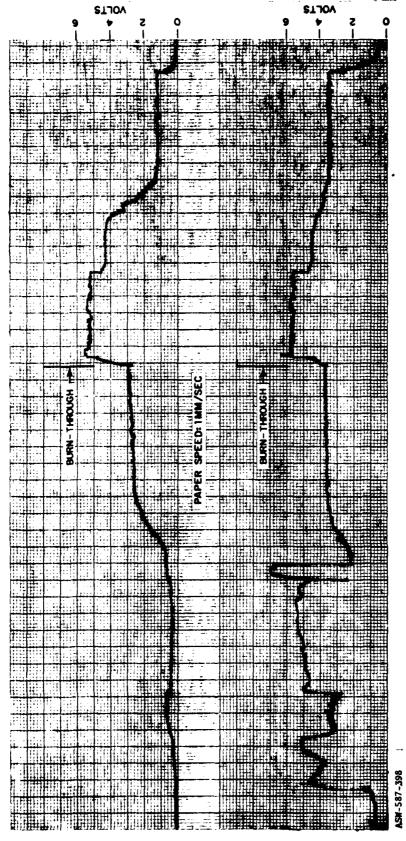
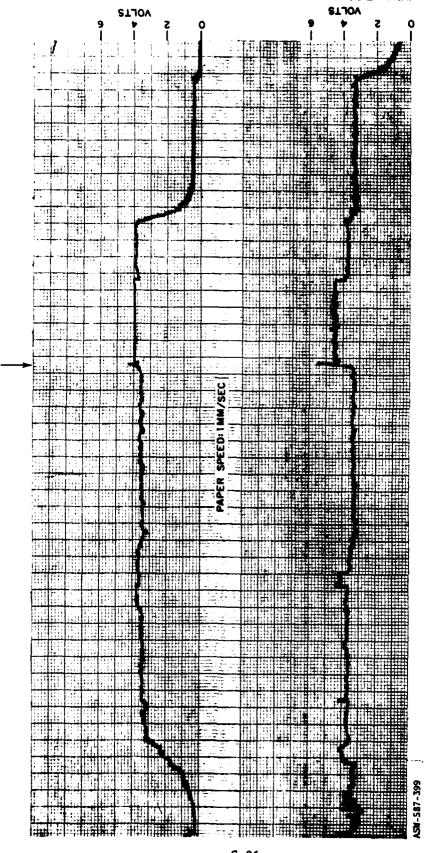


Figure C-31, Microphone No. 3 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.



Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full. Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. Figure C-32.



BURN - THROUGH

Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. Figure C-33.

APPENDIX D

J-57 STARBOARD ENGINE FUEL LINE FAILURE

D.1 J-57 STARBOARD ENGINE FUEL LINE FAILURE

The J-57 starboard engine was modified by opening the engine housing and puncturing the fuel line leading to the modified burner can. The housing opening was welded closed and the test performed. The engine was run up to maximum RPM and fuel turned on to the ruptured line. Burn-through occurred shortly thereafter and the engine was immediately shut down.

Analysis of this run appears on pages D-2 through D-12.

D.1.1 Analysis

D.1.1.1 Sound Energy Levels

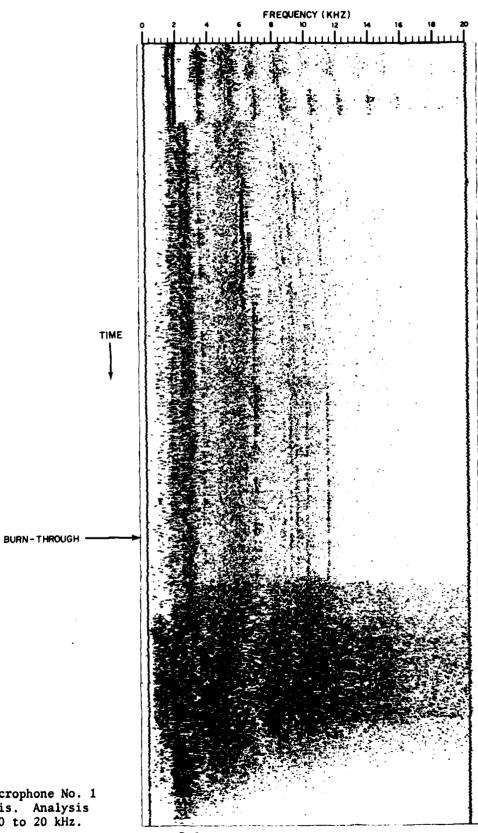
No readings were taken.

D.1.1.2 Spectrum Analysis

All grams were similar to closed-hole tests. Discrete machinery frequency lines were present up to 11.5 kHz and some broadband random noise was present up to 20 kHz prior to burn-through. At burn-through, intense broadband random noise was generated. The proximity of the microphones to the point of burn-through was directly related to the intensity of the random noise on the grams.

D.1.1.3 Mean Square Analysis

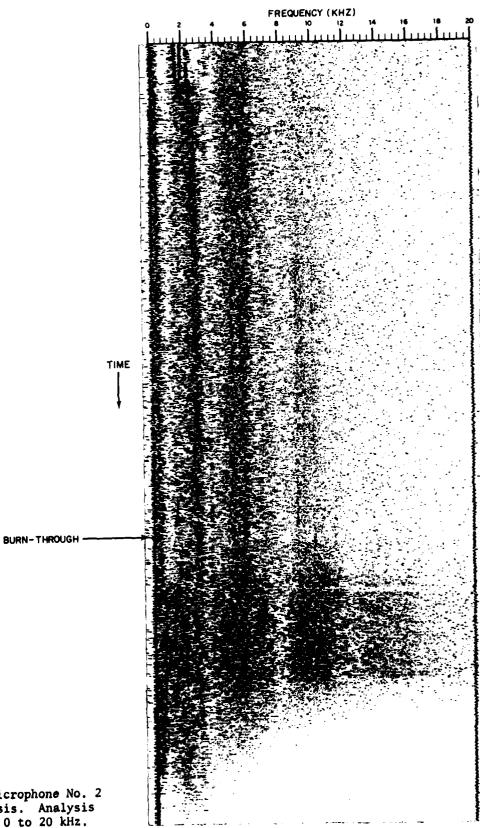
The burn-through was more pronounced on all grams than for any previous burn-through test. Low frequency components discussed in appendix B, which are characteristic of this type engine, were again evident. The burn-through spectral content was primarily above 5 kHz.



ASW-587-400

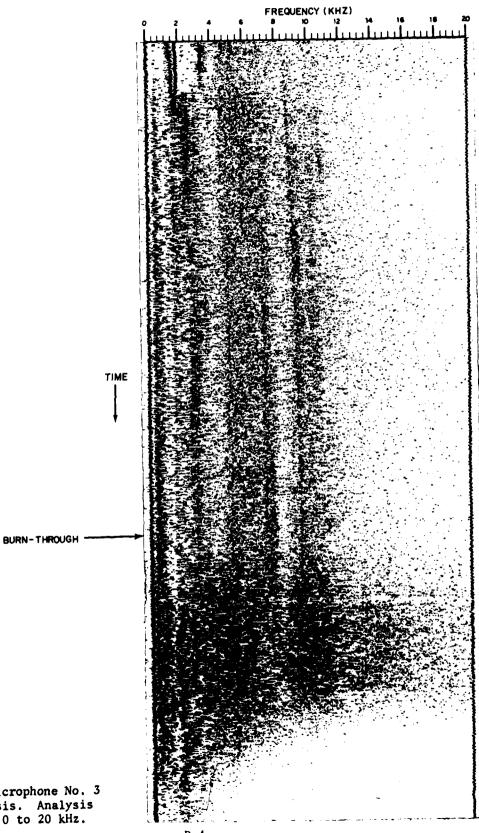
Figure D-1. Microphone No. 1 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

D-2



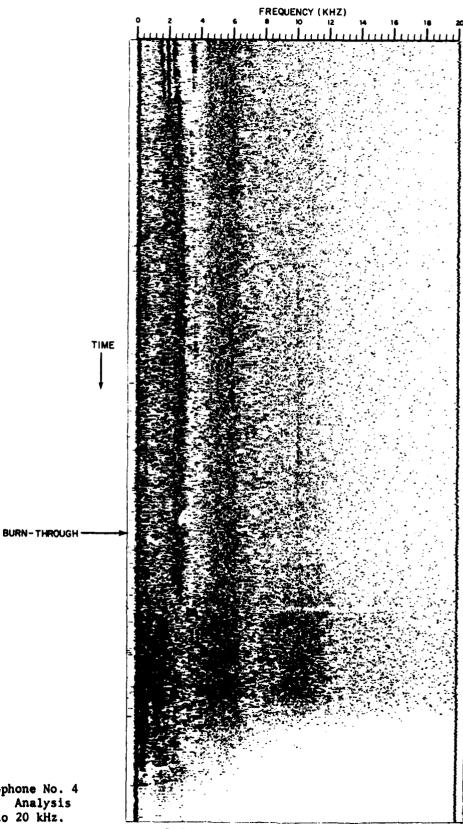
ASN-587-401

Figure D-2. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



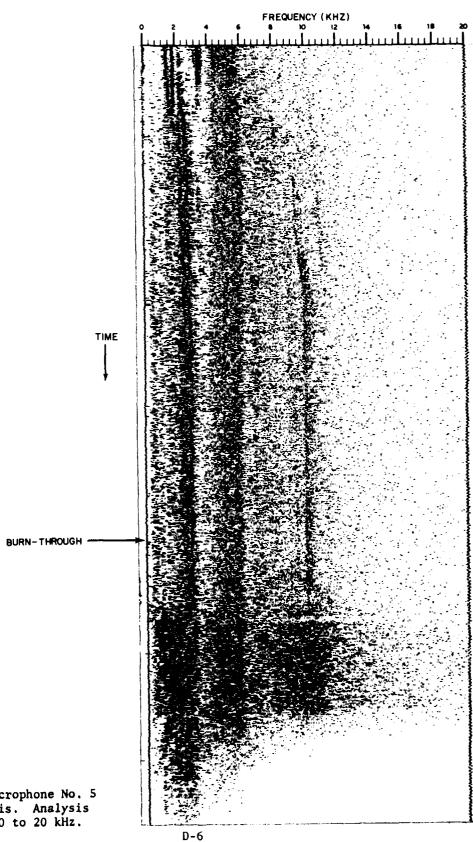
ASW-587-402

Figure D-3. Microphone No. 3 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

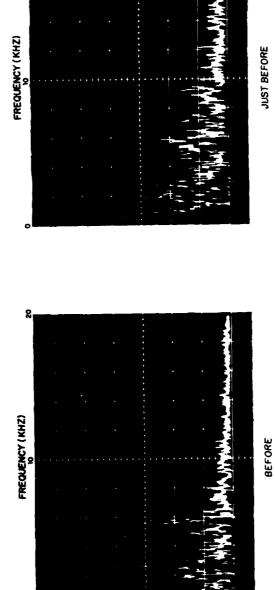


ASW-587-403

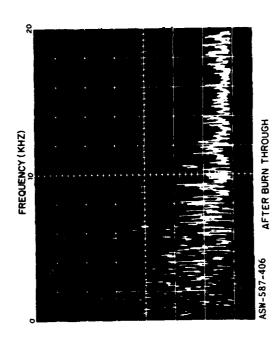
Figure D-4. Microphone No. 4 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



ASW-587-404 Figure D-5. Microphone No. 5 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.



1



ASW-587-405 INITIAL BURN THROUGH
Figure D-6. Microphone No. 2 Spectrum Analysis.
Analysis Bandwidth is 0 to 20 kHz.

Figure D-7. Microphone No. 2 Spectrum Analysis. Analysis Bandwidth is 0 to 20 kHz.

D-7

FREQUENCY (KHZ)

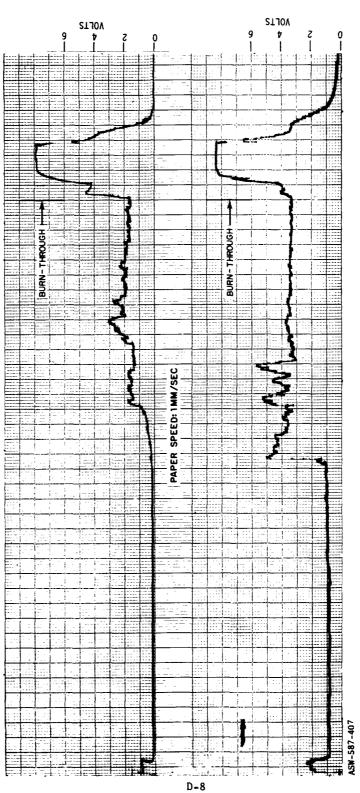
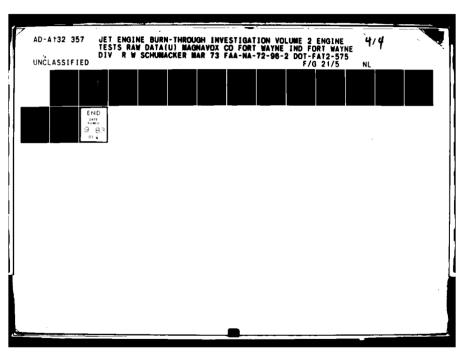
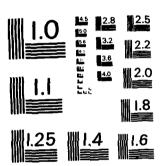


Figure D-8. Microphone No. 1 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

Fig





MICROCOPY RESOLUTION TEST CHART NATIONAL BUREAU OF STANDARDS - 1963 - A

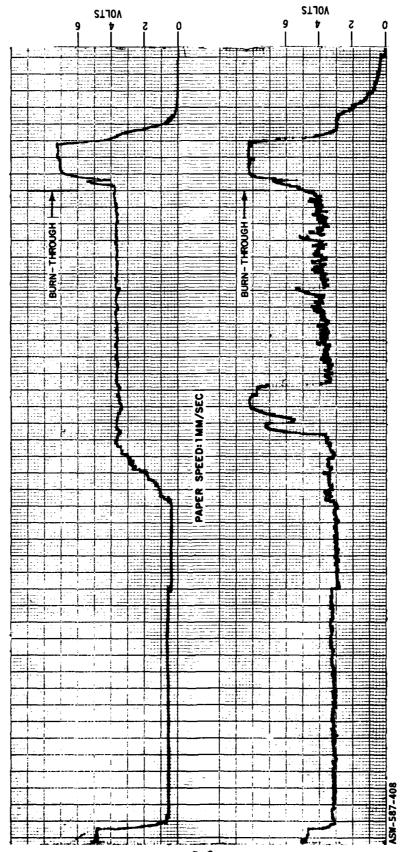


Figure D-9. Microphone No. 2 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

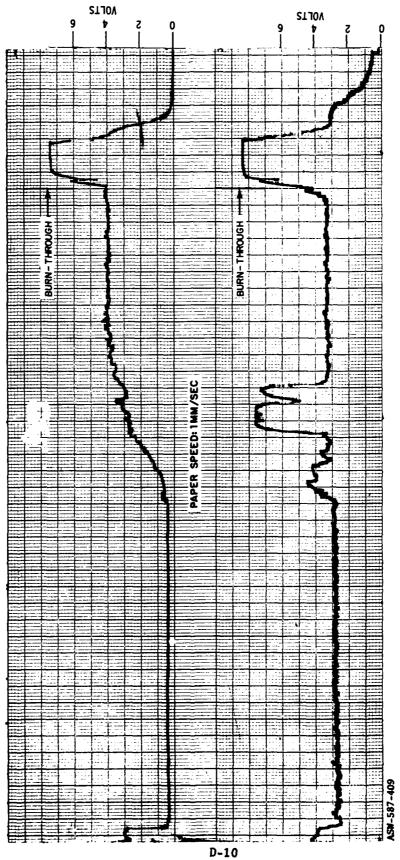


Figure D-10. Microphone No. 3 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.

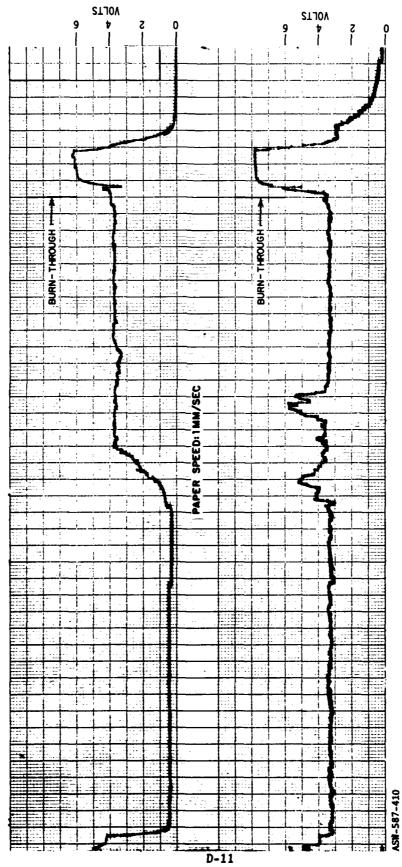
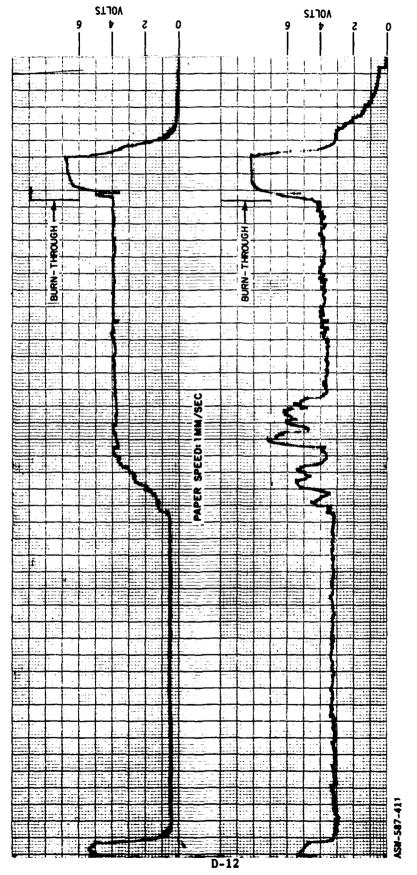


Figure D-11. Microphone No. 4 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz.



Microphone No. 5 Mean Square Analysis. Analysis Bandwidth of Lower Trace is Full Recorded Bandwidth; of Upper Trace, 5 to 20 kHz. Figure D-12.

APPENDIX E

MICROPHONE CHARACTERISTICS

E.1 MICROPHONE CHARACTERISTICS

Two types of microphones, with markedly different characteristics, were used during the recording phase of the program. The wide rangy microphone was a condenser type, Bruel and Kjaer, Model 4138, with a type 2619 preamplifier. The two parts, microphone and preamplifier, formed an integral unit. The general-purpose microphones were Shure Brothers, model 515SB dynamic types with direct coil outputs.

- E.1.1 Bruel and Kjaer 4138 Characteristics:
 - (1) Frequency response (See figure E-1.)
 - (2) Open circuit sensitivity at 1 kHz (microphone and preamp) $80.4~\mu V/\mu BAR$
 - (3) Buffer amplifier loss 16 dB
 - (4) Overall sensitivity 12.8 μV/μBAR
 - (5) Output voltages for typical Sound Pressure Level values
 - a. 20 μ BAR (100 dB) = 256 μ V
 - b. 2.0 mBAR (140 dB) = 25.6 mV
- E.1.2 Shure 515SB Characteristics:
 - (1) Frequency response (See figure E-2.)
 - (2) Open circuit sensitivity at 1 kHz 89 μV/μBAR
 - (3) Output voltages for typical Sound Pressure Level values at 1 kHz
 - a. $20 \mu BAR (100 dB) = 1.78 mV$
 - b. 2.9 mBAR (140 dB) = 178 mV
 - (4) Noise response because of the pronounced hump in the microphone response at 5 kHz, the response to noise of uniform spectral density differs from that for a sine wave at 1 kHz.

A first approximation to the "white" noise response may be obtained by assuming an even distribution of noise in a 0- to 10-kHz band with a total received power of 1 watt. Thus, each 1-kHz segment of the spectrum contributes 100 mW to the received power. The microphone output power will be different in each 1-kHz band, however, because of the irregular response.

Letting 0 dB stand for unity power gain through the transducer, the output power for each 1-kHz segment of the 1-kHz band is approximately as follows:

BAND (KHZ)	OUTPUT (mW)
0-1	80
1-2	130
2-3	160
3-4	180
4-5	250
5-6	400
6-7	400
7-8	200
8-9	100
9-10	60
0-10	1960

The output power in the 10-kHz band would be 1.96 W giving the microphone a "gain" of 2.9 dB in that band. Thus, the response to white noise in a 10-kHz band is 2.9 dB higher than that to a sine wave of equivalent amplitude at the 1-kHz reference frequency. In the 10-kHz band then, white noise gives the following:

- a. Open circuit sensitivity 125 mV/ μ BAR
- b. Typical outputs:
 - 1. 20 μ BAR (100 dB) = 2.5 mV
 - 2. 2.0 mBAR (140 dB) = 250 mV
- E.1.3 Conversion of Output Voltage in mV to Sound Pressure Level in μBAR and dB

(Reference =
$$2 \times 10^{-4} \mu BAR$$
)

Using the relationships established above, the input Sound Pressure Level for a given microphone may be inferred from its output voltage ($^{\rm V}_{\rm O}$). For the B and K microphone, the reverse transfer function is

Sound Pressure (µB) =
$$\frac{2 \times 10^{-3} \text{ V}_{0}}{25.6 \times 10^{-3}} = 0.0783 \text{ V}_{0} = 78.3 \times \text{(Value of V}_{0} \text{ in mV)}$$

Sound
$$\frac{V_o}{Pressure}$$
 (dB) = 20 log $\frac{V_o}{0.00256 \ \mu V}$ = 100 + 20 log $\frac{V_o}{256 \ \mu V}$ Level

For the Shure microphone, the reverse transfer function is

Sound
Pressure (µB) =
$$\frac{2 \times 10^{-3} \text{ V}_{0}}{250 \times 10^{-3}} = 0.008 \text{ V}_{0} = 8 \times \text{(Value of V}_{0} \text{ in mV)}$$

Sound Pressure (dB) = 20 log
$$\frac{V_o}{0.025 \text{ }\mu\text{V}}$$
 = 100 + 20 log $\frac{V_o}{2.5 \text{ }m\text{V}}$ Level

These equations are plotted in figures E-3 and E-4 for reference.

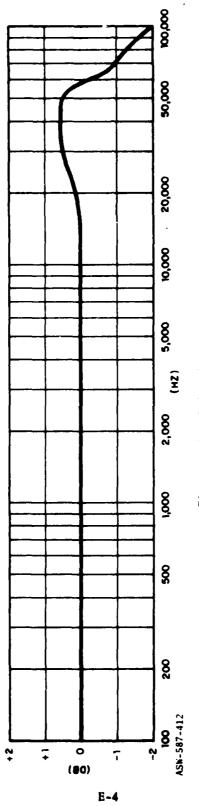
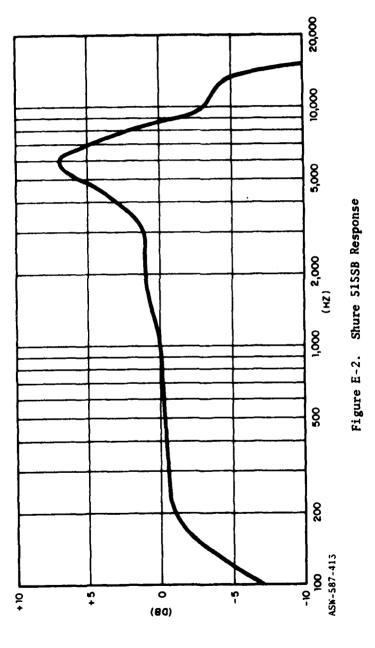


Figure E-1. B & K 4138 Response



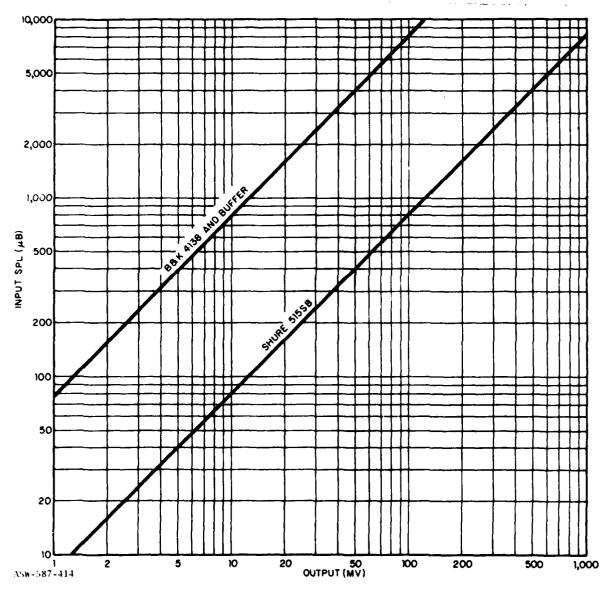
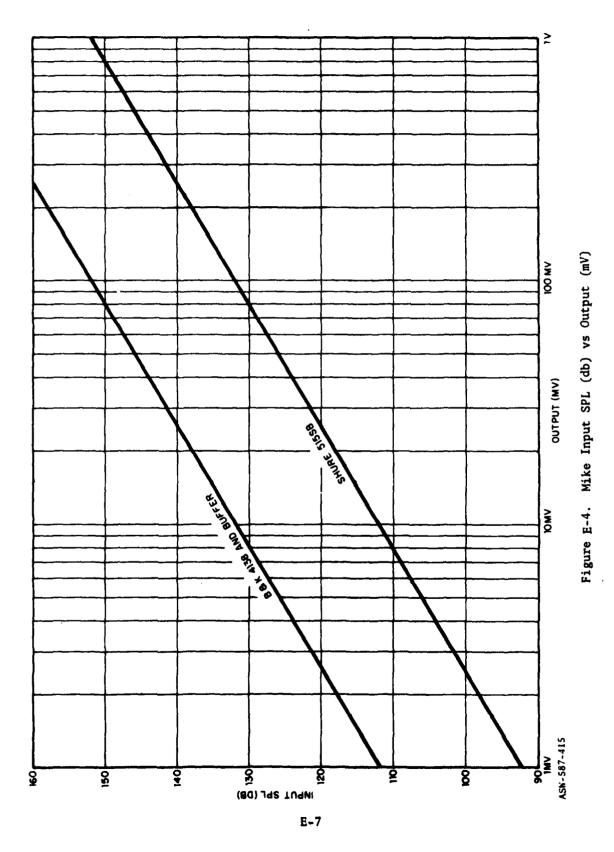


Figure E-3. Mike Input SPL (μB) vs Output (mV)



APPENDIX F

RECORDING AND ANALYSIS EQUIPMENT LIST

F.1 RECORDING EQUIPMENT

- (1) Magnetic Tape Recorder 7 Channel, 1/2" tape Model: Sangamo 3562 Serial No.: 4315
- (2) Microphone (4)
 Low impedance
 Model: Shure 515SB
 UNIDYNE B
- (3) Microphone (1) 1/8" Cartridge, Type 4138, B & K Instruments, Inc. Serial No.: 363842
- (4) Microphone Adaptor (1) 1/8" - 1/2", B & K Instruments, Inc. Type UA0036
- (5) Microphone Preamplifier (1) B & K Instruments, Inc. Type 2619
- (6) Microphone Power Supply B & K Instruments, Inc. Type 2801
- (7) Monitor Scope, Five Channel Calico Monitor Scopes
 Calico Instruments Corp.
 Model: 7211
 Serial No.: 345
- (8) Monitor Scope
 Tektronics Type 545B
 Serial No.: 008741
 Type CA Plug-in
 Serial No.: 017251
- (9) Power Supply
 Harrison Labs Model No. 800A-2
 Serial No.: MU 1883-08
- (10) Amplifier
 Hewlett Packard Type 465A
 Serial No.: 38289-1

- (11) RMS Meter
 Ballantine Model No. 300
 Serial No.: 18948
- (12) Voice Microphone Shure Model 215S
- (13) Playback Audio Amplifier and Speaker Magnavox Co.
- (14) Buffer Amplifier Special Design Magnavox Co.

F.2 SPECTRUM ANALYSIS EQUIPMENT

- (1) Magnetic Tape Recorder 7 Channel, 1/2" Tape Sangamo Model 3562 Serial No.: 4315
- (2) Spectrum Analyzer, Ubiguitous Federal Scientific Corp Model No.: UA-7B Serial No.: 35246-5
- (3) Oscilloscope, Monitoring Tektronix Model No. 801RL Serial No. 007929
- (4) DC Amplifier
 California Instrument Co.
 Calico Model No.: 3300A
 Serial No.: 110
- (5) Paper Recorder
 Reytheon Co.
 Model No.: PER-196B-6
 Serial No.: 085
- (6) Playback Audio Amplifier and Speaker Magnavox Co.

F.3 MEAN SQUARE ANALYSIS EQUIPMENT

- (1) Magnetic Tape Recorder 7 Channel, 1/2" Tape Sangamo Model 3562 Serial No.: 4315
- (2) Band Pass Filter
 Krohn-Hite Model No. 330MR
 Serial No. 19390
- (3) True RMS VTVM

 Balantine Laboratories, Inc.

 Model No.: 320A

 Serial No.: 8426
- (4) R-A-P Voltmeter
 Balantine Laboratories, Inc.
 Model No.: 321
 Serial No.: 730
- (5) Dual Channel DC Amplifier Recorder Sanborn Company Model No.: 320 Serial No.: 34064-1

END

DATE FILMED